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Deep in the forest primeval

THE cover picture shows the power-station building at Wairakei, New Zealand, together with the steam pipelines which have been installed to bring geothermal steam from bores situated up to two miles away. The first turbo-alternator was commissioned in November 1958. The installation of plant for 150 MW has been authorized. Mr. Wheatcroft's article on p. 83 gives a description of the project. The photograph is published by courtesy of the New Zealand Government National Publicity Studios

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THE FLY IN AMBER

'THERE is a history in all men's lives, Figuring the nature of the times deceas'd, The which observ'd, a man may prophesy, With a near aim, of the main chance of things As yet not come to life.' Thus Shakespeare, and who could put it better? This is, perhaps, the mainspring of the study of the past; and in our sphere of engineering the idea is surely not less worth pursuing.

The life of the chartered electrical engineer is, so we say, more mundane, less poetic. His life, we suppose, follows a pattern, just as his world-wide achievements reflect order and progress.

If we think about it at all, we no doubt carry in our minds a picture of the previous generation of electrical engineer, representing the archetype, the distillation of all our experience of him. We see him, perhaps, an earnest, dignified, hard-working figure, practising his profession with single-minded devotion.

But what sort of experience did he have? How does he differ from the present generation? When a man has lived and died, his personality is incommunicable to those who never met him. So the personality of the class, their distinctive aspect, is lost from one generation to the next. There is one way only in which we can evoke the outline of that dead corporate personality or, to use a Victorian simile, faintly catch the authentic accents of the past. We can study their lives as presented in their writings, in their achievements. Best of all, we can study their lives as unfolded in those last friendly tributes we call obituary.

An objective assessment must concentrate on the pattern of facts, ignoring comment and opinion; and such a scrutiny of the obituaries published in the *Journal* during the last three or four years has a special interest of its own. This idle survey may have nothing more of significance to tell us than a completed crossword; on the other hand, we might learn something.

160 obituaries were published in the *Journal* during the period covered by our review—160 records of the life and work of the members, honorary members and compa·ions who departed the scene at a time of unpa·alleled expansion in the world of electricity—an expansion which they had fostered. Only 37 of those men went to a university, while 53 served an apprenticeship. Remembering that the average age at death was 73½, this picture of training is much as one would have guessed. It is typical of professional education in the early years of this century.

Their connection with The Institution is of interest: 46 had been Student or Graduate members, 52 held office, and 22 had papers published in the *Proceedings*.

Some idea of the sort of job they did emerges from another set of figures. Only five of those apprenticed stayed for any appreciable period with the same firm after serving their time. 35 out of the 160 took a post abroad, and nine of these stayed abroad their whole working lives. Fifty-nine served in the Forces. Of those with a well-defined career, 17 devoted themselves to research, 20 to manufacture, 25 to power supply, 42 to administration, and five to selling, while eight became teachers and eight journalists. 'Miscellaneous' claimed 28.

These are facts which would seem to contradict the thesis that chartered engineers do not make administrators. It seems possible that the proportion entering a sales career has increased somewhat lately. The question almost arises whether, even on these figures, the number not actually practising as electrical engineers is not too high.

The 'miscellaneous' division shows a notable spread. Nine became consultants, others contract engineers and electrical and engineering advisers. One became a chief motor-transport officer, two made the Services their career, two became solicitors and two surveyors.

115 of them married, and 95 of those had children—an average of two apiece.

In sport and hobbies also there is a definite 'average

man'. His sport is golf (23 out of 33 where a sport is mentioned) and his hobby gardening (27 out of 78). But convention slinks from the scene in the face of the variety of pastimes adopted by the subjects of our study. Tennis, swimming, cricket, football, bowls and hockey are joined by curling, ice-hockey and polo. Music is second only to gardening among hobbies, but reading and shooting are up among the leaders, with fishing, photography and motoring vying for position just behind. Walking and cycling are popular, and so is yachting. Scientific hobbies such as archaeology, entomology, geology, astronomy, ornithology, horology, and solving mathematical puzzles are represented, as well as billiards, bee-keeping and painting.

Fencing finds a solitary exponent, but woodwork and cabinet making (wood also—or on paper?), bridge and chess all have their enthusiasts.

They retired, on average, at 65, so they had, again on average, 8½ years in which to practise to the full those hobbies and pastimes for which, no doubt, their busy professional lives had left them so little time.

John was their most common name, a record which, in *The Times* newspaper, is maintained to this day.

And so, survived eight times out of ten by his widow, the chartered electrical engineer of yesterday is parted from us. What has this superficial glance at his life taught us? No more perhaps than that while the eternal controversies over education, training, science, engineering and the arts and humanities have raged, these engineers have been exemplifying in their own unself-conscious manner the ideal of balanced living and breadth of expression in career and personal life for which the pundits appeal today.

Perhaps the next generations succeeding these men, and particularly the youngest of them, may similarly confound the prophets of doom by finding for themselves, in spite of the swaddling-bands of specialization, the same dimension of freedom and maturity, the same far-ranging interests, as these their predecessors so evidently did. The strongest intellectual strait-jacket must be loosed by the irresistible forces surging through the life of the professional engineer.

Standardization of the yard and the pound

FROM the 1st July 1959 the national standards laboratories of the United States and five Commonwealth countries, including the United Kingdom, will use international yards and pounds for all non-metric calibrations involving length and mass (unless otherwise required).

This is the outcome of recent discussions between the directors of the National Bureau of Standards, Washington; the Applied Physics Division, National Research Council, Ottawa; the Dominion Physical Laboratory, Lower Hutt, New Zealand; the National Physical Research Laboratory, Pretoria; the National Standards Laboratory, Sydney; and the National Physical Laboratory, Teddington.

The international units to be used are defined as follows:

1 international yard = 0·9144 metre
1 international pound = 0·453 592 37 kilogramme

The Board of Trade point out, however, that, although conforming with the recommendations of their departmental committee on Weights and Measures Legislation (the Hodgson committee), the new international units will have no statutory force in the United Kingdom and may not be used for trade purposes in this country. The units for trade are the imperial standards laid down in the Weights and Measures Act, 1878.

Expressed in terms of the metre, the values of the yard currently in use in the Commonwealth and the United States are:

1 imperial standard yard = 0·914 3972 metre
1 N.P.L. yard = 0·914 398 41 metre
1 Canadian yard = 0·914 4 metre
1 United States yard = 0·914 401 83 metre

The yard used by the National Physical Laboratory for science and technology is based on the 1922 value of the imperial standard yard. The imperial standard yard is at present about 5 parts in a million (0·0002 in.) less than the United States yard and is shrinking at the rate of over 10^{-6} in. per annum.

The N.P.L., by using the metre and wavelengths of light and by adopting the 1922 value of the imperial standard yard, has been able to stabilize its basis of reference for length measurements in terms of the yard and its common submultiples for science and technology; but it is obvious that unification of the yard standard for these purposes in the Commonwealth and the United States can no longer be delayed. The discrepancies in length measurements are now becoming most important in modern precision engineering.

The agreed international yard falls between the existing United States and British units, being, in fact, the same as the Canadian yard. It accords exactly with the relationship:

1 in. = 25·4 mm

which is already extensively used here and abroad for approximate conversions.

At present there are three 'pounds' in use:

1 imperial standard pound = 0·453 592 338 kilogramme
1 United States pound = 0·453 592 427 7 kilogramme
1 Canadian pound = 0·453 592 43 kilogramme

The imperial standard pound appears to have diminished by about 7 parts in 10 million since 1846 and is about 2 parts in 10 million (0·0014 grain) smaller than the United States and Canadian pounds—which are defined in terms of the very closely safeguarded international prototype kilogramme.

611.81 STORAGE AND MANIPULATION OF INFORMATION IN THE BRAIN

Much attention has been given recently to the problem of understanding more about the working of the brain. The main obstacle is the difficulty of investigating the subject empirically. It will be a long time before one can say with confidence exactly what happens internally as a child accumulates experience over the years of growth and what happens when the stored experience determines his reactions in later life. This article suggests some lines of thought which it is felt may be found relevant when more is known.

Dr. Beurle presented the lecture on which the article is based at the Ordinary Meeting on the 20th March 1958. The lecture was given also to the South-West Scotland Sub-Centre on the 8th April and to the East Anglian Sub-Centre on the 27th October 1958.

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ASSOCIATE MEMBER

THE behaviour of living things has been studied from various angles. The zoologist, the sociologist and the psychologist observe from outside. The neurophysiologist, the anatomist and the biochemist are more concerned with aspects of the internal structure. Their task in some ways is harder because of the serious technological difficulties in investigating even the simplest interactions between nerve cells and because of the vast number involved.

The communication engineer has a complementary interest in the storage and manipulation of the incoming information and its relation to the consequent behaviour. What are the possibilities of correlating behaviour, observed externally, with neuron interaction observed internally? At the moment, precise comparison is impossible, because of lack of empirical data; and there is no established theory although many suggestions have been put forward.

The approach to the problem

Numerous comparisons have been made between the brain and various complex mechanisms. Unfortunately it is only too easy to invent simple electronic and mechanical mechanisms which behave in a way to some extent analogous to some form of animal behaviour, but this does not tell us very much. The approach to be outlined here starts from our knowledge about the interaction between nerve cells. If we knew precisely how the cells in the central nervous system interacted, it should, at least in principle, be possible to say how this system would react to incoming stimuli. In fact, the difficulty is not so much conceptual as practical, namely that we have insufficient empirical data. Nevertheless, by taking the information that is available, we can form some idea of the nature of the activity which may exist.

The complexity of nervous systems

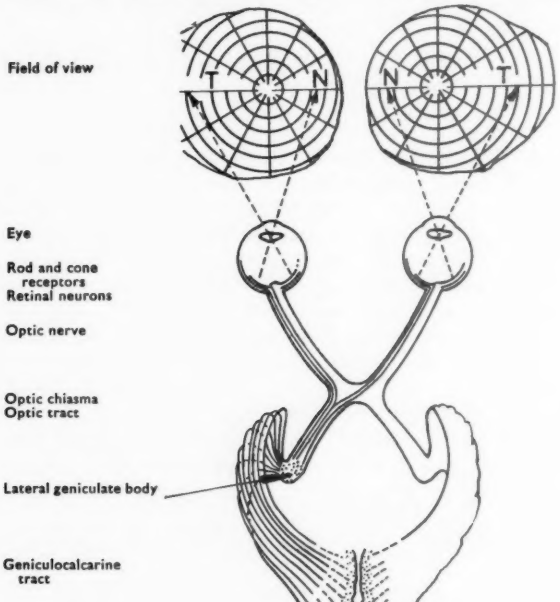
The simplest single-cell animals appear to respond solely on a chemical basis. More advanced animals develop specialized cells for receiving information, specialized nerve cells for carrying the information, and muscle cells for action. Together, these form what are called 'reflex arcs', which enable the organism to react appropriately to incoming stimuli. By mutation and natural selection over a long period of time, reflexes have been established in the species which give reactions to the advantage of the organism in its natural habitat.

As we go up the evolutionary scale, these primitive reflex arcs, giving a predetermined inherited response to a fixed stimulus, are no longer adequate: more versatility is required. The individual animal must be prepared to experiment with its environment and discover the most appropriate responses, and so learn to adapt itself to the environment in which it finds itself. In this it is helped by the fact that, even though its world may not be as simple as that of the more primitive organisms, there is still a good measure of consistency. There is a good chance that a response learned by trial and error on one occasion will suffice in a similar future event.

A corresponding plasticity is required in the nervous system, and this is introduced by controlling the simple reflexes rather than replacing them. Moreover, just as the simple response is controlled by a slightly more advanced nervous system, so, in turn, the action of this latter may be subject to control. In man there appears to be a whole hierarchy of control systems superimposed one upon another. When some new activity, such as brushing the teeth, is learned, it is seldom necessary to establish every movement in the process afresh. The individual will already be able to control his hand and arm muscles to pick up visible objects and transfer them to his mouth. He may also be able to recognize a tooth-brush without having used it. All that is required is to combine these abilities, with a little experimentation

once the toothbrush is in the mouth, to get the right brushing motion.

All the complicated actions that we learn are built up little by little like this, on the groundwork that we have learned earlier. Those familiar with digital computers will recognize an analogy with the use of a number of sub-routines which are brought together when a new programme is worked out.



1 *The visual pathway*
N=Nasal T=Temporal

The simplicity of each step in a learning process means that we do not have to look for any essentially complicated process in the part of the brain which is modified. This may be no more complex basically than the brain of the simplest living thing that can learn.

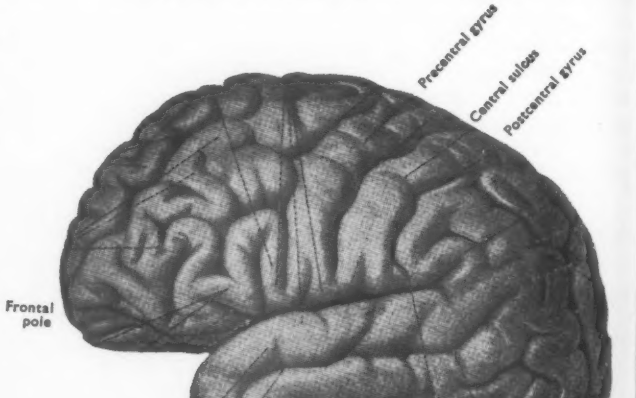
The material basis

Now let us look at the type of material that we are dealing with, the central nervous system. In vertebrates we have the spinal cord, which swells out at the upper end into a number of units which together form the brain. Each of these units contains vast masses of neuron cells, and bundles of millions of fibres run between them. It is very difficult to trace these fibres, although certain important multiple pathways are well known, for example the visual pathway in which nervous impulses pass successively from the receptors in the eye, via the retinal neurons and the optic tract to the lateral geniculate body, and thence via the geniculocalcarine tract to the visual cortex (Fig. 1). These sensory pathways are not mere inert communication channels; but the transformations through which the information goes at intermediate stages are not yet fully understood.

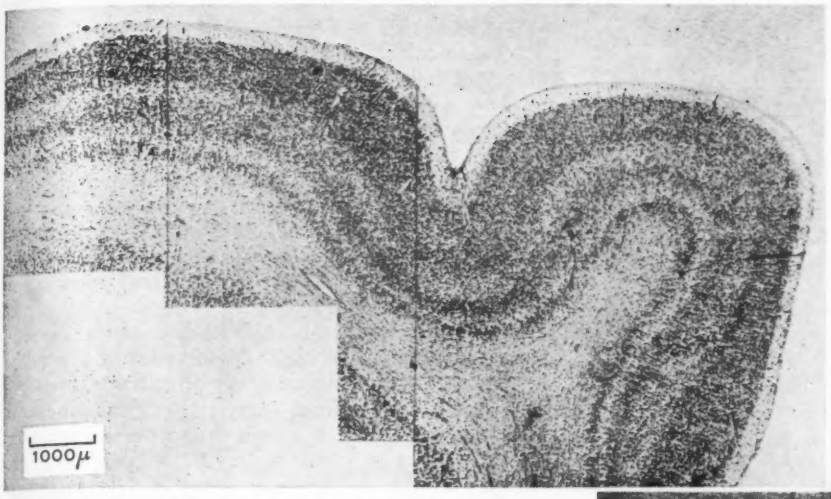
The general pattern of connections between the various units does not vary much from one individual to another. On the other hand, a marked feature of the structure of some of the individual units is the very large chance factor which appears to enter into the establishment of connections between the nerve cells of which they are composed. This is in contrast to the connections between the individual components in, say, a digital computer, which must be made precisely according to some prearranged circuit diagram. For illustration, Figs. 2 and 3 show the cerebral cortex, the most prominent feature of the brain and from the evolutionary point of view the most recent. In man, the cortex contains approximately 10^{10} neuron cells. Fig. 4 shows the large number of bundles of incoming and outgoing fibres running up from, and down to, the white matter. Fig. 5 shows the cell density in the grey matter.

Each cell has two sets of branching fibres through which it establishes connections with other cells (Fig. 6). Many cells also have a single axon fibre which descends to the white matter, and pyramidal cells have the single ascending 'apical dendrite' shown in Fig. 6. Apart from this, the branching fibres show little regularity or pattern, and the only plausible hypothesis appears to be that connections are established largely as a result of chance contacts between fibres of neighbouring neurons.

Another interesting feature, which recurs at various points in the brain, is the 'mapping' of incoming sensory data in certain regions. This again can be illustrated with reference to the cortex. Fig. 7 shows a cross-section through the postcentral gyrus. If sensory receptors on



2 *Side view of the left cerebral hemisphere*
The cerebral cortex is a layer of grey matter immediately below the surface



3 (left) *Cross-section through one lobe in the visual cortex*

There is an obvious distinction between the grey matter (cells and fibres) near the surface and the white matter in the centre (fibres only, covered with white fatty insulator myelin)

4 (below) *Enlarged cross-section of cortex*

This has been treated to show the large number of incoming and outgoing bundles of fibres going between the white matter (below) and the grey matter (above). These are fibres coming in from sensory organs, fibres going out to motor organs, and fibres connecting together various parts of the brain

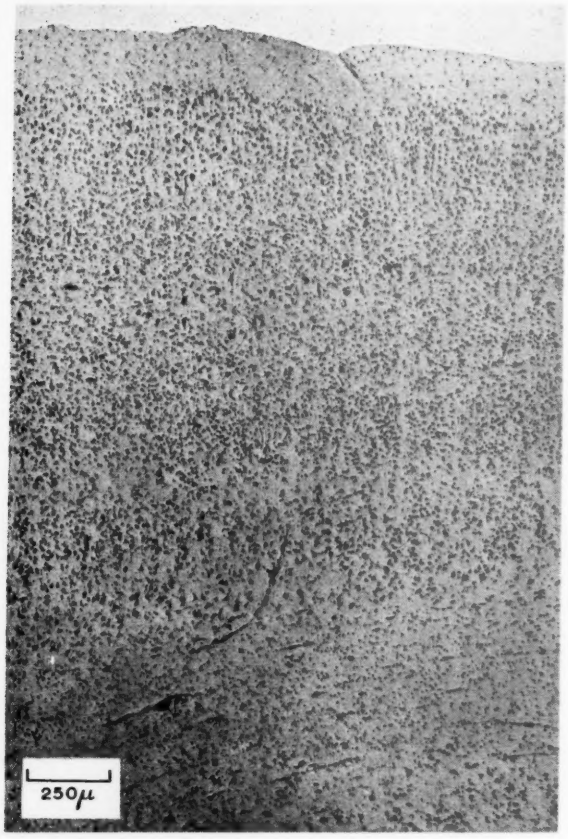
various parts of the body are stimulated, electrical activity tends to occur on the surface of the cortex approximately in regions indicated by the figurines drawn alongside. This is consequently called the somatic sensory cortex. Similarly, Fig. 8 shows figurines superimposed on a cross-section through the precentral gyrus. This is known as the motor cortex; electrical stimulation of this region is apt to cause muscular action in the corresponding parts of the body.

We thus have incoming sensory data arriving on one part of the cortical surface and motor action influenced by a neighbouring part. The whole area between and surrounding these parts is one continuous mass of cells. How can this mass of cells and all these straggling fibres possibly be organized in such a way that they act as an effective link between the two? Information is not merely relayed to its correct destination, but in some way information about events is recorded as they occur, so that future behaviour can be modified by past experience.

Interaction between cells[1]

When a neuron cell becomes 'active', information is carried along the axon in the form of an electrochemical impulse. The potential difference normally present across the membrane which separates the inside of the fibre from the surrounding liquid vanishes when the membrane is discharged. It is as though the axon were a pulse transmission line with distributed amplification and pulse-shaping properties. After each pulse there follows a period during which the cell and fibres slowly recover to the original state of equilibrium. Energy dissipated during the cycle is supplied ultimately by the metabolic activity of the cell.

Information passes from the axon of one cell to the cell body or dendrites of another, via connections known as 'synapses'. In the spinal column a small swelling called a 'terminal bouton' forms on the axon where it makes synaptic contact with the other cell. It is uncertain whether these are present in the cortex, but it is generally agreed



5 *Cell density in the cortex*

This section has been processed to show cells, but not the interconnecting fibres. The complexity of the pattern of connections will be appreciated when one recalls that the connection-fibre system of each cell may be several hundred microns across

that synaptic connections do exist. Within the embrace of the dendritic fibres of one cell are several thousand other cells with which it may make chance contacts.

The precise properties of the synapse are uncertain. It is thought that each cell has a threshold: it does not become active on the arrival of a single impulse at a synapse but requires a number of impulses to trigger it off. It also appears that the cell threshold varies, or the growth or effectiveness of a synapse may increase slightly with use. Certainly something must change with activity in the cortex in order that information may be stored at all, and there is some empirical evidence that one or other of these changes occurs in certain spinal neurons where tests are more easily carried out.[1]

This information is subject to some uncertainty. Much of our knowledge is based on neurons outside the cortex, and the properties of cortical neuron cells *en masse* may well be different in some respects. Cortical neuron cells might, for instance, affect each other via the electric fields they produce, as well as by synaptic action.

Corporate activity of a mass of cells

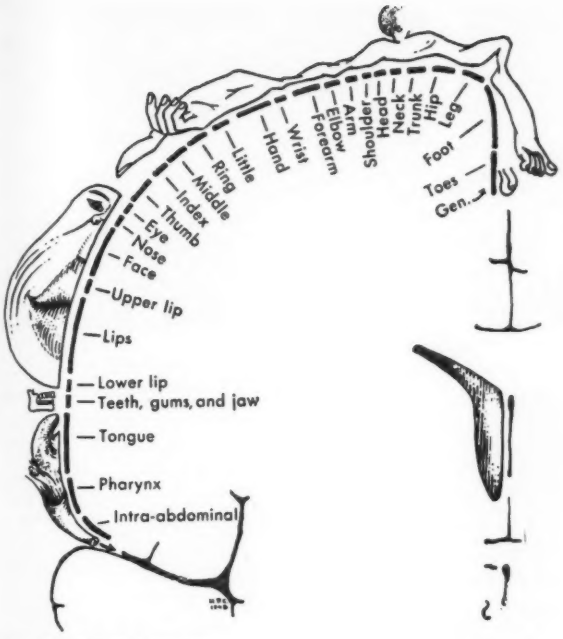
What we are really interested in is the basic properties of a randomly connected mass of cells. Let us suppose we have a hypothetical mass of cells, that these have properties similar to the known properties of neurons, and that the probability of connection between pairs of cells falls off with distance, as one would expect from the decrease in density of axon and dendrite fibres of a cell as we go further from the cell body. What forms of activity can such a mass of cells support?

The answer is that this depends to a very great extent on the quantitative aspects of the parameters mentioned above, but the more important features can be demonstrated very simply. In Fig. 9 the initiation of a surge of activity in a 2-dimensional array of cells is illustrated. In a small 2-dimensional array it is difficult to show what might happen in a vast 3-dimensional mass of

6 *A typical pyramidal neuron cell*

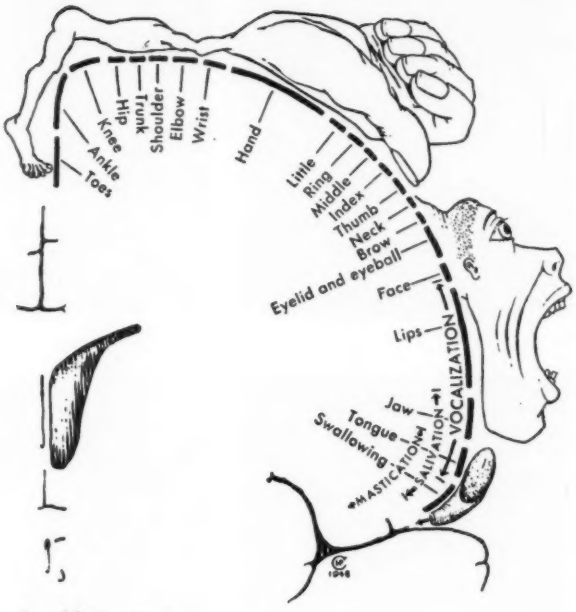
The thicker fibres branching in all directions from the body of the cell are known as dendrites. The axon fibres are thinner, and all branch from the single axon fibre descending vertically from the cell body in the illustration. The downward continuation of this axon through the white matter carries information to motor organs or to other parts of the brain.

Stellate cells do not have the ascending apical dendrite which is typical of the pyramidal cell



7 *Somatic sensory area*

This is a cross-section through the postcentral gyrus. The figurines indicate the extent of cortical surface on which electrical activity tends to occur when different parts of the body are stimulated. Note that the cortical area is proportional to the complexity of the incoming information and not to the body area involved



8 *Motor cortex*

This is a cross-section through the precentral gyrus. The figurines indicate the regions of the body where muscular action is liable to be produced by stimulating different points on the cortex. Note that the cortical areas involved are proportional to the complexity of movements required rather than to the mere volume of muscle

neurons, so this illustration must be interpreted as giving only a general diagrammatic indication of what may be expected in a large mass.

The important points to note are that a relatively small stimulus may produce no obvious reaction. To initiate self-maintained activity we must stimulate a number of neighbouring points simultaneously or within a fairly short period of time. These features bear a similarity to the excitability of the cortex, which shows a similar spatial and temporal summation of stimuli.[1] Such behaviour has been noted in very simple organisms.[2]

Because the only form of interaction assumed to exist between cells is excitatory, the activity in Fig. 9 tends to be of an 'all or nothing' character. Once it builds up we get a powerful surge of activity in which neighbouring cells all fire synchronously and every cell in the array is involved as the surge passes through. In the cortex this type of all-powerful 'saturated' surge of activity is not apparent under normal conditions. It seems that in the cortex there must be some stabilizing influence controlling the activity at an intermediate level.

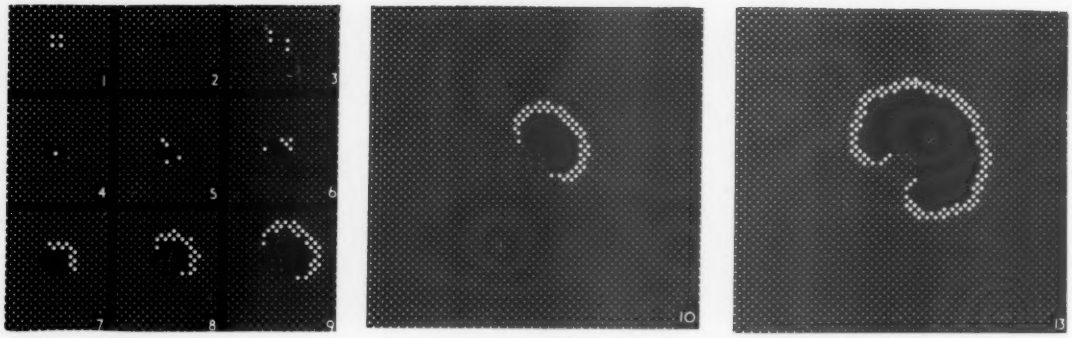
Some form of inhibitory interaction would suffice. Inhibition is known to exist elsewhere in the nervous system, but there is no direct evidence for it in the cortex. We can only assume some stabilizing influence in our hypothetical cell mass without implying any assumptions as to what form it might take in the cortex. We may then expect unsaturated activity, with only a proportion of cells taking part at any one time (Fig. 10).

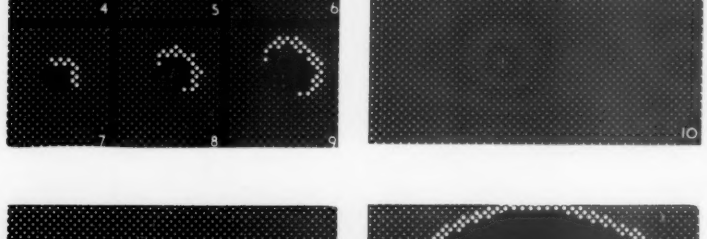
Unsaturated activity is important because in any given region of a mass of cells it is possible, by applying different stimuli, to initiate any one of a number of unsaturated surges of different constitution. The constitution, i.e. the identity of the cells which become active during the passage of the activity, depends on the launching stimulus and thus represents it. By activating a selected proportion of the cells and thus changing some parameter of these cells, the unsaturated activity records its occurrence.

The trial-and-error learning principle

The most important property of the mass arises from the fact that individual cells are assumed to increase slightly in sensitivity each time they become active. As a result, the attenuation of the medium for unsaturated activity of given constitution decreases each time that activity passes through it. This gives the medium the ability to change with experience, or 'learn'.

Fig. 11 has been prepared to demonstrate this fact. It represents diagrammatically the very simplest organism in which one can demonstrate the learning propensities of the mass of cells. The cell mass is represented by the central rectangle. To the basic cell mass have been added an input organ and an output organ. These are obviously





9 *Activity surge in a 2-dimensional cell array*

1. Four cells, shown as large white dots, have been activated by an external agency
2. These cells have ceased activity after scattering excitation among their neighbours. This excitation is insufficient to cause spontaneous activation of any further cells. The fact that the four cells are temporarily out of action is indicated by the absence of the white dots
3. Four more cells are activated by external means
4. The combined excitation has finally resulted in spontaneous activation of a single cell
5. Four further cells are artificially activated. This has really started something
6. Five cells have been spontaneously activated.

In periods 7–10 the activity spreads rapidly outwards. From period 8 onwards the cells activated earlier begin to recover their sensitivities
The activity continues to travel outwards, and, at the same time, the cells which were originally active during the first cycle become sensitive again
The process continues as shown in period 20

essential if the mass is to interact with the outside world. There are also the 'discriminators of inherently satisfactory and unsatisfactory situations', the action of which will shortly become clear.

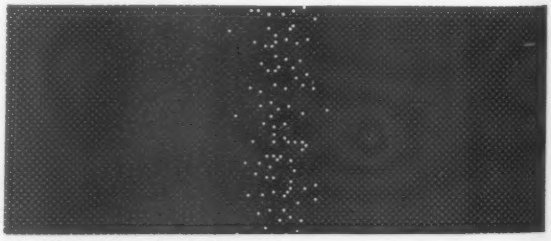
Suppose some event takes place in the outside world and activity is allowed to spread across the mass of cells. If the mass of cells is initially quite randomly connected, the point at which the activity first reaches the motor output region will be the result of pure chance. The motor action caused will also be the result of chance.

Now there are two possibilities: one, that the resulting action is appropriate in the environment and produces a satisfactory reaction from the outside world; the other, that the action provokes an unsatisfactory reaction. In the former case the discriminator of satisfactory situations will allow the same form of activity to continue to propagate, and a low-attenuation path will be formed through the medium from input to output. This allows the same environment to produce the same appropriate response in the future. If the action provokes unsatisfactory results, the other discriminator operates. It inhibits the activity immediately and prevents the unwanted low-attenuation path being established through the mass of cells. Thus, in time, the mass of cells builds up low-attenuation paths only to those responses which are satisfactory in the environment.

To demonstrate trial-and-error learning, the very minimum has been added to the basic mass of cells. The necessity for the input and output organs is obvious. With regard to the discriminators, it might be remarked that one could hardly have trial-and-error learning unless something, somewhere within the organism, specified what was to be learnt.

The conditioned-response principle

We have seen how a mass of cells in this simple hypothetical organism may adapt itself by trial and error to its environment. In real life we seldom come across a completely new environment, or one which is completely familiar. What happens in these circumstances? There is still a trial-and-error element in the response, but it is inherent in the properties we have assumed that the mass will always tend to produce as a trial response the one that has been found satisfactory in the most nearly similar circumstances in the past.



10 *Unsaturated activity*

A well defined surge of activity is shown travelling from left to right. Some way behind the region of activity, cells which have previously been active are beginning to recover sensitivity

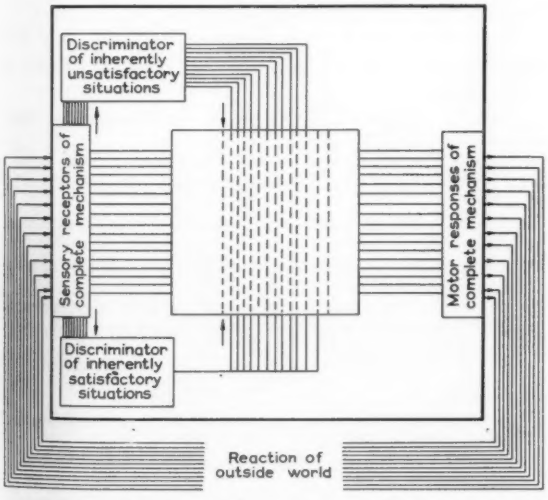
A response can be transferred in this way from one stimulus to another. Thus, if a stimulus X produces activity which reliably leads to a given response x, then another stimulus Y occurring simultaneously will produce activity which tends to become merged with that of the first stimulus and still leads to the same response x. If X and Y together are allowed to continue to produce this merged activity, it becomes well established. Eventually, it becomes possible to drop the stimulus X, without deflecting the activity sufficiently to lose the response x. The modifications to the medium during the simultaneous occurrence of X and Y form a 'memory trace' that 'associates' X and Y.

The significance of this will be appreciated if we recall the experiments of Pavlov. In 1902, he found that the flow of saliva which normally came when food was presented to a hungry dog could also be initiated by a sound, if that particular sound had been presented together with the food on many occasions in the past. Here a response (salivation) has become transferred from the original stimulus (food) to the new stimulus (sound). This is known as the 'conditioned response', and similar behaviour has been confirmed in relation to other stimuli and responses.

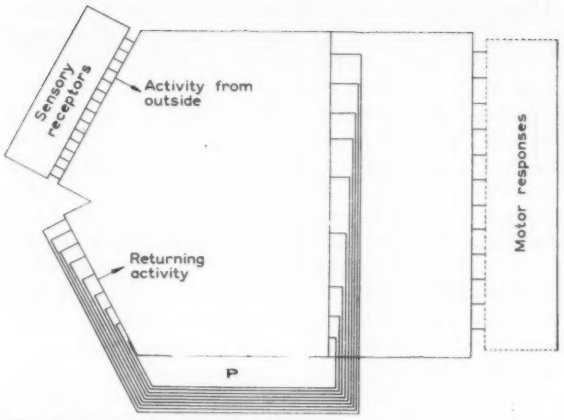
The conditioned response enables the organism to choose a relatively likely response to a new environment. It thus eliminates some of the waste of time and effort inherent in pure trial-and-error learning. Nevertheless, this tentative response is treated like the pure trial-and-error responses in that it is subject to reinforcement or suppression, according to its success or failure in providing satisfactory adaptation to the environment.

The regenerative-memory principle

An even more powerful means of eliminating trial and error arises if activity caused by external events can


Discriminator of inherently unsatisfactory situations
Sensory receptors of complete mechanism
Motor responses of complete mechanism
Discriminator of inherently satisfactory situations
Reaction of outside world

11 *A simple hypothetical organism to illustrate 'trial and error' learning*



12 *Memory of a sequence of events*

circulate in a loop. Fig. 12 illustrates a mass of cells with a set of fibres running from the output region back to the input region. If an external event A is immediately followed by an event B, then surge A will pass through the cell mass from left to right. Having reached the output region, it will be returned again to the input region, to travel through the mass again. Here it will interact with the following surge B, and with the medium, to record the fact that B followed A. This record will be a memory trace of the same kind as that which produced the conditioned response.

Similarly, each pair of events, B followed by C, C followed by D, etc., record their sequential coincidence as time goes on, and the memory traces become strengthened every time a particular sequence occurs. The extraction of this recorded information is very simple. All that is necessary is to allow one outside event, say event A, to initiate a surge of activity in the medium, and then to cut off incoming information. Let us suppose that B has followed A on many occasions. Then surge A, after it has travelled through the mass and back through the R fibres, will interact with the medium to reconstitute a surge of activity similar to that produced by event B. Surge B may reconstitute surge C and so on, each surge following in sequence as though the corresponding events were actually happening in the outside world. These events are not necessarily recalled in the precise sequence in which they happened on one past occasion but in the 'most probable sequence' as measured by the frequency of occurrence of succeeding events in the past experience of the organism.

A sequence of most probable events recalled from past experience is, by its very nature, also a train of thought about the future. This simple basic organism is thus capable not only of retrospection but also of speculation. This adds greatly to its ability to choose suitable forms of response to novel situations.

We have been talking about our hypothetical mass of cells as though it were communicating directly with the outside world through simple transducers, the sensory receptors and motor responses. In fact, in any but the

simplest animals the situation is vastly more complex. A mass of neuron cells such as the cortex is usually reacting to an environment in which its immediate neighbours are other parts of the brain and in which communication with the outside world in the ordinary sense is achieved only via a number of intermediate links. The principles outlined above are none-the-less important, because the ability to learn by trial and error, to show the conditioned response, and to record and reproduce sequential memories is really inherent in the mass of cells and not in the complexity or otherwise of the channels by which communication is maintained with the outside world.

Short-term memory

So far, the only form of memory that has been discussed is what we might call long-term memory, resulting from relatively permanent modifications to cell properties. It has been suggested that short-term memory might consist of circulating activity in ring chains of neurons. The two forms of memory might play a complementary part. In fact it would simplify the application of the principles that have been discussed here if the short-term memory should be found to bear the functional relationship to the long-term memory indicated in Fig. 13.

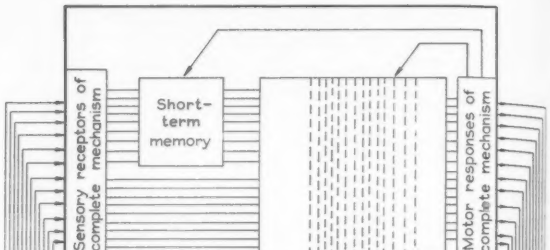
Discussion

During the discussion following the presentation of the lecture, it was generally agreed that the rate of information intake could be very high for short periods. This fact, together with the loss of recent memories after a shock, could be regarded as evidence for the existence of a short-term memory mechanism distinct from the faculty of long-term memory. The author considered that the effect of local damage could readily be explained on the theory he had outlined, because confirmatory information could travel by many independent paths. Damage to a few of these would not produce serious disorganization. He felt that the detection of small time intervals might be explained on a similar basis. Duplication of the measuring mechanism, followed by an averaging process, would smooth out the errors.

Regarding the absence of any explanation of the alpha rhythm, the author felt that it was only too easy to invent plausible explanations for such features as the alpha rhythm, but it was not so easy to select the right one.

An interesting conclusion

How valid is the picture which has been drawn here? It is possible that it is in fact a true description, as far as it goes, of some of the principles which are important in the working of the brain, but there is so much uncertainty about the empirical data that one must regard it as very tentative. Biologically, the whole idea is very plausible. Random connections are, by their very nature, simple to specify with a minimum of information and could well be conceived as part of a self-reproductive organism, while from the evolutionary aspect no difficulties arise.


Short-term memory
Sensory receptors of complete mechanism
Motor responses of complete mechanism
Excitatory and inhibitory discriminator
Reaction of outside world

13 *A possible relationship between short-term memory and long-term memory*

We cannot yet relate behaviour in any detail with the structure of the brain, but there is little doubt that our understanding will advance rapidly as our knowledge increases. Until we are more certain of the fundamental basis it is premature to follow out all the interesting implications for those fields of study whose meeting point lies in the brain. The interesting conclusion is that there is a real possibility of correlating some of our behaviour with the structure and activity of the brain, once we know enough about the latter.

Acknowledgments

The author wishes to thank the General Manager of the English Electric Valve Co. Ltd. for permission to publish the article. He would also like to thank the many friends with whom he has had the pleasure of discussing the subject, in particular Mr. D. A. Sholl.

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HOMANS, J.: 'Textbook of surgery' (C. C. Thomas Co., 1945) (Fig. 1)

RANSON, S. W., and CLARKE, S. L.: 'The anatomy of the nervous system' (W. B. Saunders, Philadelphia and London, 9th ed., 1953) (Fig. 2)

SHOLL, D. A.: 'The organisation of the cerebral cortex' (Methuen, 1956) (Figs. 3, 4, 5 and 6)

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ELECTRICITY FROM GEOTHERMAL STEAM

On the 15th November 1958 the Wairakei geothermal station began supplying power to the New Zealand Grid. This marked the beginning of the commissioning of the first part of the Geothermal Steam Project, whereby some of the natural thermal sources in New Zealand's North Island are being harnessed to provide electric power on a large scale. The project is controlled by the New Zealand Government, and operation of the power station is in the hands of the New Zealand Electricity Department.

This article uses some of the material contained in a paper entitled 'Production and utilization of geothermal steam', by J. H. Smith, which was read in Wellington on the 10th April 1958 at a meeting of the New Zealand Institution of Engineers at which the Presidents of the three Home Institutions were present. Mr. Wheatcroft is with Merz and McLellan, the consulting engineers for the project.

E. L. E. WHEATCROFT, M.A., MEMBER

ONLY during the last few years has a determined effort been made in New Zealand to drill for and utilize steam from geothermal sources on a large scale. Hot water or low-pressure steam from shallow bores has been used for many years on a small scale for heating purposes in some of the thermal areas, notably Rotorua, but not until 1950 was exploration by drilling commenced with a view to ascertaining the possibilities of obtaining steam of a quality suitable for driving turbines to generate electric power.

Since then, exploration drilling by the New Zealand Ministry of Works has been done at Wairakei and at Kawerau and at the present time is being continued at Wairakei (in the outer area) and also at Waiotapu.

Exploitation of the steam field at Kawerau has been successfully accomplished by a private company, which uses the steam for process heating; while at Wairakei the drilling of production bores has reached a stage where sufficient steam to generate approximately 150 MW is available from bores, and a power station to generate 69 MW as a first stage of development is being commissioned.

Plans are in hand for the extension of the station to 150 MW, and further expansion to 250 MW is contemplated when sufficient bores have been completed.

1 *Thermal areas of New Zealand*
The thermal zone is indicated by shading

Geological conception

Wairakei is one of the larger active thermal areas which lie in the volcanic zone extending in a north-easterly direction for about 150 miles, from the volcanoes in the centre of the North Island to White Island in the Bay of Plenty. The width of the belt varies but averages about 20 miles for the middle third of its length, where most of the areas worthy of consideration for exploitation are situated (Fig. 1).

The geological conception of the belt is that a section of the earth's crust has stretched and allowed a block to downfault and form a graben and that subsidiary faulting within the graben has given a complex structure of faulted blocks in the basement rock (greywacke).

Subsequent infilling of the depression with volcanic breccias, flows and sediments, probably several thousand feet thick, provides the present-day upper layers which prevent the detailed structure of the belt from being determined. Faults in the upper layers are common.

Many are still active and indicate that downfaulting is still continuing at depth. Thermal activity is undoubtedly connected with such faulting.

Natural heat flow

The larger areas within the volcanic zone, together with an estimate of their natural heat flow, are as follows:

Area	*Natural heat flow* 10^6 B.Th.U./h (relative to 0° C)
Waiotapu	3080
Wairakei	2040
Orakeikorako	1860
Rotokawa	740
Tikitere	570
Te Kopia	430
Kawerau (Te Teko)	290
Waikiti	290
	9300

It is evident that the best opportunity for exploitation by drilling is in a locality where the natural heat flow is large, but the amount which can be taken off by bores without overdrawing cannot be predetermined. The natural heat flow is an indication of the minimum amount available to shallow bores but not much of a guide to the maximum which can be withdrawn by deeper drilling. It would appear that only by drilling and producing from bores can the full potential of an area be ascertained.

Bores drilled at Wairakei

Fig. 1, a map of the North Island of New Zealand, shows the location of the thermal area. The initial exploratory bores, mostly of 4in. diameter, were sited on a line cutting across the Wairakei geothermal area in a general east–west direction between the Wairakei and Waiora streams (where high concentrations of thermal activity occur); there were also two further bores to the south near Karapiti blowhole.

These bores provided information regarding the nature of the geological formations and underground temperatures down to 1500ft below the surface and defined promising localities. Testing of bore discharges for quantity of steam and water, gas content of the steam and chemical content of the water showed that utilization was practicable. (Some of these bores are in fact used to supply the power station.)

A limited production-drilling programme then commenced, a few 6in.-diameter bores being sunk to depths of 1000ft. These all produced steam satisfactory for use at moderate pressure.

With the arrival of larger drilling rigs, however, and the success of the first 8in.-diameter bore, which was 2000ft deep, all subsequent production bores have been of this diameter. This 8in. bore showed that large outputs of high-pressure steam and water (at 180–220lb/in.^{2}) could be obtained from such depths and indicated that the potentialities were far greater than had previously been expected.

While with every 8in.-diameter bore drilled the object is to obtain utilizable steam, some of them should be more correctly classed as exploration bores, particularly those that are outsteps or go to greater depths. All bores provide some new information, perhaps confirmatory, and the data which have been accumulated have given a more complete understanding of the underground conditions within the depths drilled and have enabled the better producing localities to be defined.

Use of the steam for generating electricity

By 1953 it was clear that there was good prospect of winning sufficient steam to generate about 20MW of electricity, and consulting engineers were appointed to report on how this should be done. Three important questions had to be considered.

First, whether the nature of the gases and solid impurities was such that it would be advisable to delay any full-scale use until experience had been gained with a small pilot plant. Secondly, what special precautions would be needed to minimize the possibility of troubles or short life if full-scale plant were decided on. Thirdly, whether the power station should be located adjacent to the Waikato River, which would give the advantages of direct cooling but would mean transmitting steam from the wells to the power station, a distance of a mile or more.

Separation of water from steam was also a matter of major importance, since the yield of an average well contained boiling water and steam in a ratio of about 5 : 1. Not only was it necessary to separate out this large volume of water, to overcome the problem of transmitting water with the steam and to avoid water being carried over into the turbines, but also, as mentioned later, much of the corrosion problem could be solved if certain constituents were carried away in the liquid phase.

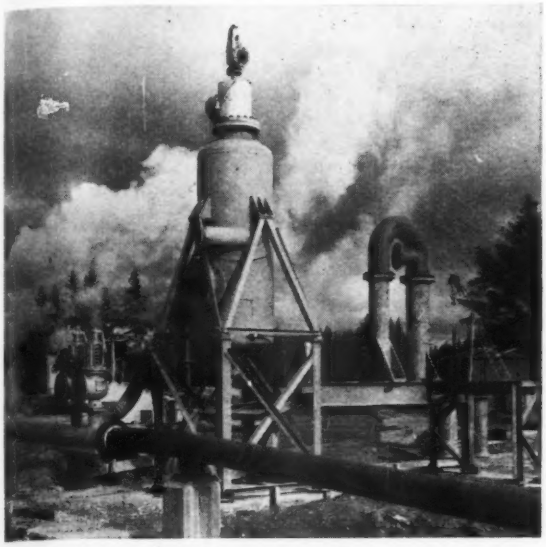
Analyses of the steam and water

The New Zealand Ministry of Works had already developed a successful primary separator consisting of a simple inverted U-bend which had enabled the steam and water constituents to be roughly separated for measurement and analysis. Analysis had been carried out by the New Zealand Department of Scientific and Industrial Research, and a programme of corrosion testing with samples of different metals had already yielded certain important conclusions.

The principal gaseous constituents of the steam were found to be carbon dioxide and hydrogen sulphide, while the water contained chlorides, bicarbonates, sulphates, and silicates of the alkali metals and metaboric acid. Particularly because of the content of sodium chloride, it was very desirable that all water should be completely separated out.

As regards the steam phase, the most active constituent

was undoubtedly the hydrogen sulphide, which would result in rapid corrosion in the presence of oxygen. However, it appeared to be necessary only as far as cast iron, mild steel, and low-alloy steel were concerned to take reasonable precautions to exclude



2 *Well-head equipment in construction*

oxygen at all times. Ammonia was also found to be present, which made it important to avoid using copper and some copper alloys, including the common brazing alloys. It was also necessary to give special consideration to the question of turbine-blading material.

Two types of well

Most of the wells which had been yielding for some time were shallow, yielding at a pressure in the range of 50–100lb/in.^{2} By 1953, however, success had already been obtained with the deeper wells yielding at pressures between 150 and 220lb/in.^{2}; and in view of the greater power potential of the high-pressure wells, further drilling was being continued at a depth of 2000ft or more. In addition to the shallow wells, of which some 14 will be used, yielding about 350000lb/h of steam at a working pressure of about 90lb/in.^{2}, there are now 17 usable deep wells yielding over 800000lb/h at a working pressure of about 210lb/in.^{2} (see Fig. 2.)

The existence of these two types of well meant that it would be necessary to adopt at least two working pressures in any power station, using high-pressure back-pressure turbines exhausting into an intermediate-pressure manifold fed also by steam from the lower-pressure wells. This intermediate-pressure steam could then be expanded right down to vacuum conditions, passing through further turbines to generate more power. Moreover, this arrangement fitted in with the eventual possibility of making use of the very considerable power potential of the separated hot water, by flashing off steam at lower pressures.

Full-scale plant

The expectation taht most of the future steam would be obtained at high pressure, which could be transmitted economically, decided the question of power-station location in favour of the site adjacent to the river, involving steam transmission of a mile or more.

Consideration of the corrosion tests, which, as stated above, had been carried out by the New Zealand D.S.I.R., led to the conclusion that it was reasonable to proceed with a full-scale plant, subject to certain precautions (indicated above) as to the use of materials.

A recommendation was made, therefore, to proceed with a station initially consisting of two 12MW condensing sets and one 2·5MW back-pressure set, probably duplicating this arrangement at a second stage if further winning of steam proved successful.

Proposed heavy-water distillation

Concurrently with examination of the use of steam for electricity generation, the U.K. Atomic Energy Authority had been considering its use for the distillation of heavy water, which, it was thought, might be produced comparatively cheaply by this means. Since the distillation plant would require steam at about 50lb/in.^{2} (gauge) and would exhaust at about atmospheric pressure, it was obvious that the distillation should be combined with electricity generation.

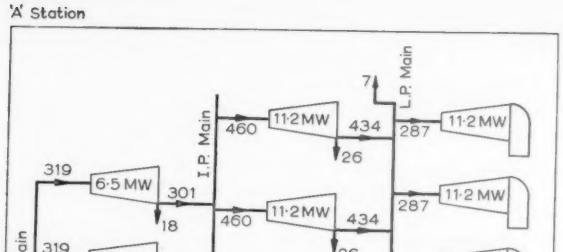
This could be done by expansion in back-pressure turbines from 180lb/in.^{2} to, say, 55lb/in.^{2}, and later by further expansion in condensing turbines from atmospheric pressure down to a vacuum. This would have involved a sacrifice of some 31% of electricity output, which had, of course, to be taken into account in considering the economics of the heavy-water production.

Based on the preliminary estimates, the New Zealand and British Governments decided in 1955 to proceed with the combined scheme, and considerable progress was made with the design not only of the well-head gear and steam transmission but also of the power station and distillation plant.

After about 12 months, however, the proposal for heavy water was abandoned, and the installation was redesigned purely for power generation. As the high-pressure back-pressure turbo-alternators and the condensing sets were already on order, one consequence of the cancellation of the heavy-water plant was that the station had to be designed for three working pressures, namely 180lb/in.^{2}, 50lb/in.^{2} and atmospheric, involving high-pressure, intermediate-pressure and low-pressure turbines. The i.p. turbines took the place of the abandoned distillation plant.

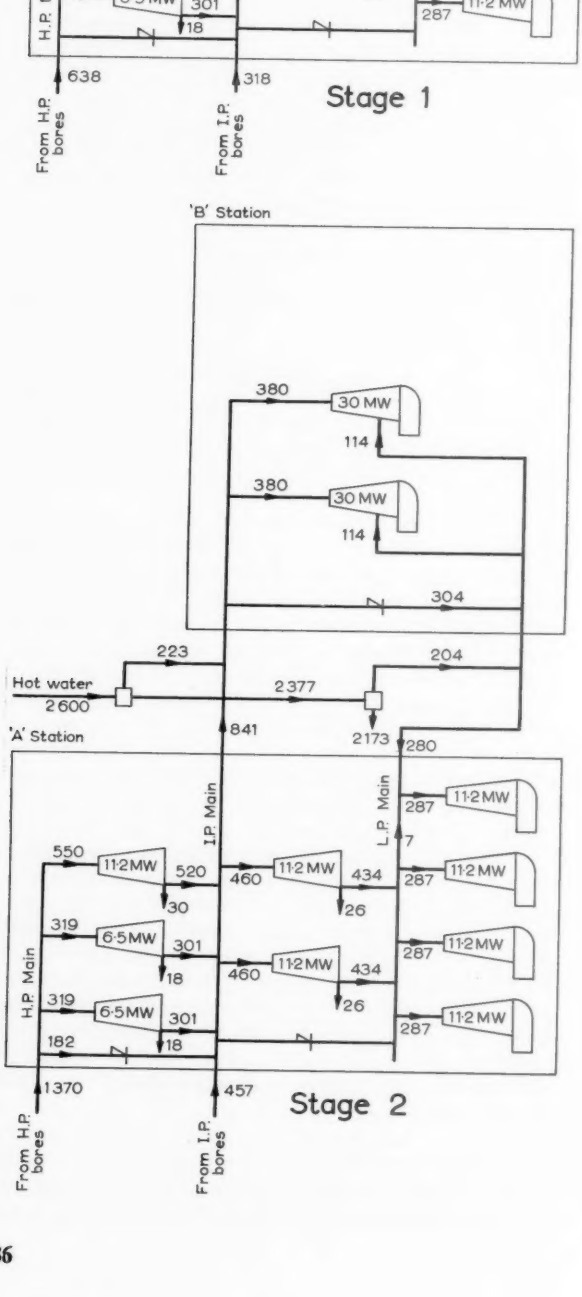
Arrangement of plant

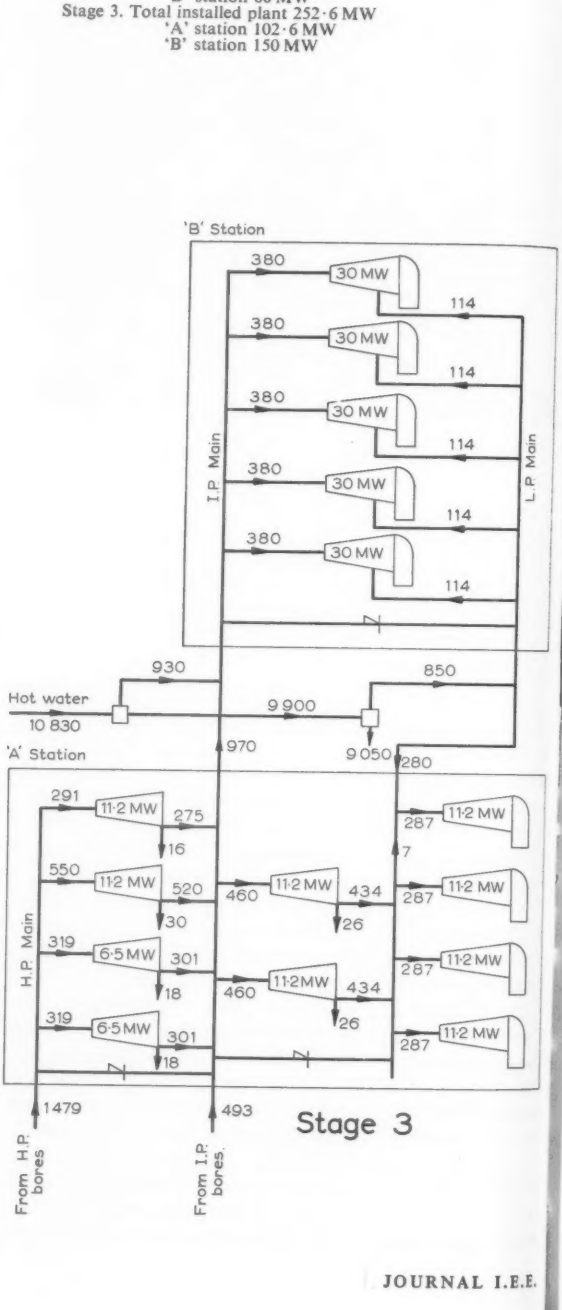
The planned ultimate arrangement of plant is shown diagrammatically in Fig. 3. The first stage consists of the



3 *Arrangement of turbine plant by stages*

Steam flows are indicated in (lb × 10^3)/h
Stage 1. Total installed plant 69 MW
Stage 2. Total installed plant 151·4 MW
'A' station 91·4 MW
'B' station 60 MW
Stage 3. Total installed plant 252·6 MW
'A' station 102·6 MW
'B' station 150 MW





two 6·5 MW h.p. sets, the two 11·2 MW i.p. sets, and three of the four 11·2 MW l.p. sets—all in the 'A' station, totalling 69 MW. The first machine was commissioned in November 1958, and the whole of stage 1 will be completed during the first half of 1959 (Fig. 4).

The second stage, already authorized, will follow the completion of stage 1 and will consist of a third h.p. and a fourth l.p. set, each of 11·2 MW, in the 'A' station and two 30 MW pass-in sets in the 'B' station.

The completion of this stage will raise the installed capacity to 151·4 MW and will enable use to be made of additional steam won from further drillings and also a moderate use of steam flashed from hot water.

A third stage would raise the total installed capacity to 252·6 MW, involving the installation of a fourth h.p. set of 11·2 MW in the 'A' station and three more 30 MW pass-in sets in the 'B' station. Most of the additional power at stage 3 would come from the hot water. The operation of the Geothermal Power Scheme is in the hands of the New Zealand Electricity Department.

4 *Cooling-water works (left) and power-station building under construction*

Transmission of separated hot water

Transmission of the separated hot water raises special problems. Separation is carried out at the well-head, and in those wells where the water is sent to waste it is passed through a throttling orifice so designed as to maintain the working pressure in the separators and hence in the steam line. The water, which is at saturation temperature, is, of course, flashed during the passage through the orifice, generating steam which passes together with the remaining water into a simple but effective form of silencer.

In the alternative arrangement, where the separated water has to be transmitted to the power station, special precautions will ensure that the water does not flash in the pipeline, as this would cause very serious danger of water-hammer and subsequent bursting.

In order to guard against this, the water will be raised above saturation pressure by being pumped up to suitable head tanks. The height of these will be such that the water will remain at above saturation pressure through the whole of its passage, taking account, of course, of friction in the pipeline and acceleration surges. The head tanks will also act as small storage reservoirs with automatic level control so that the required head is maintained in all operating conditions.

Power-station supplies

Generation is at 11 kV, the seven sets forming stage 1 in the 'A' station being connected to a 500 MVA board sectionalized into two parts. These feed through duplicate 40 MVA transformers to a pair of 220 kV transmission lines connecting to the rest of the North Island system. A pair of station transformers feeds a 3·3 kV 75 MVA board, from which a further pair of transformers supplies the various 400-volt auxiliaries. Local supply is given at 11 kV through 3 MVA transformers from a 150 MVA board.

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Summary

Thermal activity has been in evidence in the North Island of New Zealand for a long time, but it is only recently that efforts have been made to utilize geothermal steam on a large scale for the production of electricity. A considerable number of bores—some reaching 2000 ft or more in depth—have been drilled in the Wairakei area, and a number of pipelines have been installed to transmit the steam to the power station situated on the Waikato river.

Two classes of well have been developed: deep wells, which produce a steam and water mixture at pressures up to 220 lb/in.^{2}(gauge); and shallow wells, which discharge at about 90 lb/in.^{2}(gauge).

At stage 1, 69 MW of turbine plant is being installed, and a further extension (stage 2), which will bring the generating capacity up to 150 MW, has been authorized. Proposals for a third stage that will increase the installed capacity to 250 MW have been put forward.

Programme machines on the Tube

621.337.1:621-52

The signalling installations on the railways of London Transport have, for many years, provided automatic signalling on straight sections of the line. Until recently, however, a signalman has been necessary for setting the appropriate routes where junctions occur. A new system has been introduced on the central section of the Northern Line for the automatic routing of trains over junctions by means of programme machines.

In this article, Mr. Dell, who is with the London Transport Executive, describes these programme machines and their operation. He deals first with the arrangement of the apparatus, leading up to the inception of programme-machine working.

R. DELL, O.B.E., MEMBER

POWER signalling has been in universal use on the Underground Railways for more than 50 years. This type of signalling depends on the control of the signals by track circuits. For track circuiting, the running rails are divided into short sections by means of insulated joints.

A small current is fed to each section and a relay connected across the rails. When no train is present, the relay is energized, and the circuits for the signals are closed by contacts on the track relays. The wheels of a train bridge the two running rails and short-circuit the track relay, which is de-energized. The contacts of the track relay then open the circuits for the signals and put them to danger.

Special care is taken in the design of signalling circuits so that, in the event of a failure, the condition should always be a safe one.

With this system of signalling, on track free from junctions, the signals can work quite automatically, and on long sections of the Underground automatic signals have always been used.

Where junctions occur, however, it has been necessary, until quite recently, to employ a signalman to determine the route that the train should take.

Pushbutton operation by signalman

In the original installation, miniature lever frames were provided for the signalman to operate the points and signals, the circuits, in addition, being controlled by the track circuits to ensure safety.

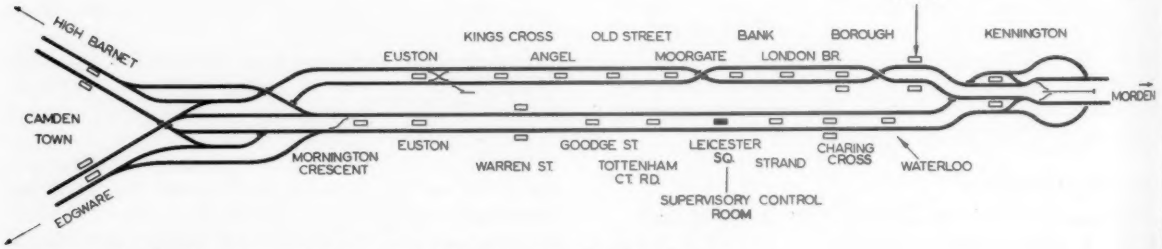
In 1952, pushbutton operation was introduced to make the work of the signalman easier. In this arrangement, the signalman sits at a desk provided with pushbuttons, each of which when pressed sets the points and clears the signal for a route.

To preserve the highest integrity required of the signalling system, an interlocking machine is employed. This really takes the place of the lever frame. In the machine are arranged a series of vertical shafts, one of which is allocated to each signal or pair of points.

These shafts are arranged to be rotated through an angle of 60° by two small compressed-air cylinders, the electro-pneumatic valves for which are operated from the circuits controlled by the pushbuttons on the signalman's desk. The vertical shafts in the interlocking machine carry a number of robust contacts, which are used for completing the circuits for the appropriate signals or points.

Mechanical interlocking between the shafts protects the system from conflicting signals being operated together. If the signal and points are set for a particular route, the shafts for the signal and points setting a conflicting route are thus mechanically locked and cannot be operated.

By having individual shafts in the interlocking machine for each signal or pair of points, these safety circuits are kept as simple as possible. The appropriate circuits from



1 *Plan of the Northern Line, which is equipped for automatic signalling throughout*

the pushbutton desk are arranged so that one route button operates the shafts for all the points and signals necessary for setting up a particular route.

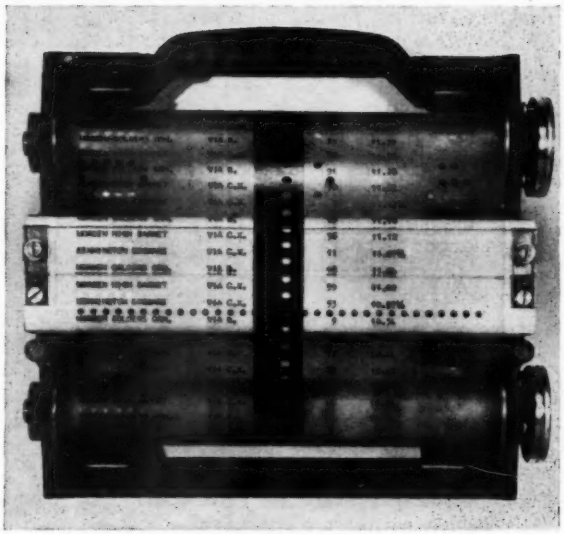
Automatic operation of junctions

The next development was to arrange the junctions so that the trains are routed automatically and no signalman is necessary.

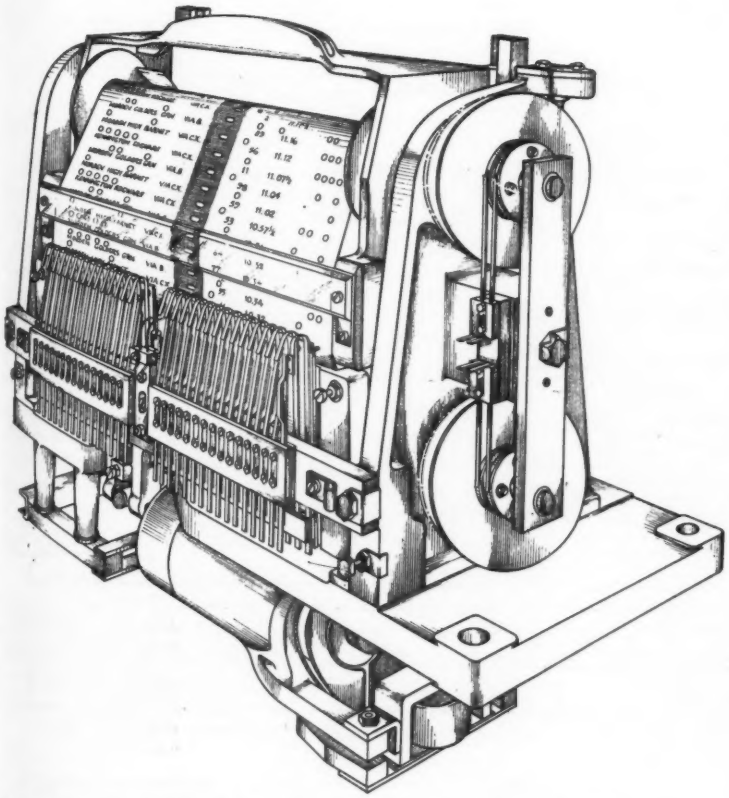
The Underground Railways are provided with train describers, which in addition to working the platform signs are used to advise the signalman of the destination of the train, and these have been incorporated in the automatic junction working.

The train describer alone is not a satisfactory means of controlling the routes of trains at junctions, as it is necessary to ensure that the trains run in their correct order, in accordance with the time-table. Programme machines have therefore been introduced to carry out the routing and timing of the trains.

The system of programme-machine control of junctions was installed in 1958 on the centre section of the Northern Line. Fig. 1 shows a plan of the lines controlled by the new system; some emergency crossovers not relevant to the working have been omitted from this plan.



3 *Programme roll on detachable carrier*



2 *Programme machine for control of signalling at railway junctions*

At Camden Town, trains from either High Barnet or Edgware can be routed either via Bank or via Charing Cross. At Euston, part of the service is reversed by a crossover, and there is provision for a train to be put into a siding. At Kennington, trains can be reversed by a loop or by means of a siding or they can be routed to Morden.

Programme-machine working of these three junctions, with all-automatic signals on the lines between the junctions, provides a section of line completely automatically signalled.

Supervision of the working is carried out in a central supervision room at Leicester Square. The operators in this room are not required to do anything for the ordinary working but are available to deal with any special circumstance, such as a breakdown, necessitating an alteration in the train service.

Programme machine

The programme machine carries the day's time-table in the form of punched holes on a roll of plastic film, 8in. wide, mounted on two rollers (Fig. 2). A line of holes across the roll provides the information for each train. The rollers are driven in either direction by a small induction motor through

magnetic clutches. Special holes near the centre of the roll operate with photocells to stop the movement of the roll when the line of holes is in the operating position.

A set of feelers is pressed on the surface of the roll, and those feelers which enter a hole close a contact which is used for setting the route or for other purposes required.

The programme roll on its rollers is detachable from the machine, so that different programmes can be inserted for weekdays or Sundays. A programme roll on its detachable carrier is shown in Fig. 3.

The working of the programme machine is that the row of feelers reads the information for a train from one line of holes, and when the routing of that train is finished the feelers are lifted from the surface of the roll and the roll is driven forward one space to bring the next line of holes under the feelers, when the feelers are again pressed on the surface of the roll.

At the end of the day, the drive is arranged to turn the roll back to the start, ready for a new day's work. A second photocell is used to stop this rewinding movement.

Fig. 4 shows a circuit diagram of the controlling circuits for the programme machine. The two germanium photocells, shown at the top right-hand corner of the diagram, control the movement of the roll. The single-stage transistor amplifier produces sufficient power to operate a telephone-type relay with the speed required for stopping the movement.

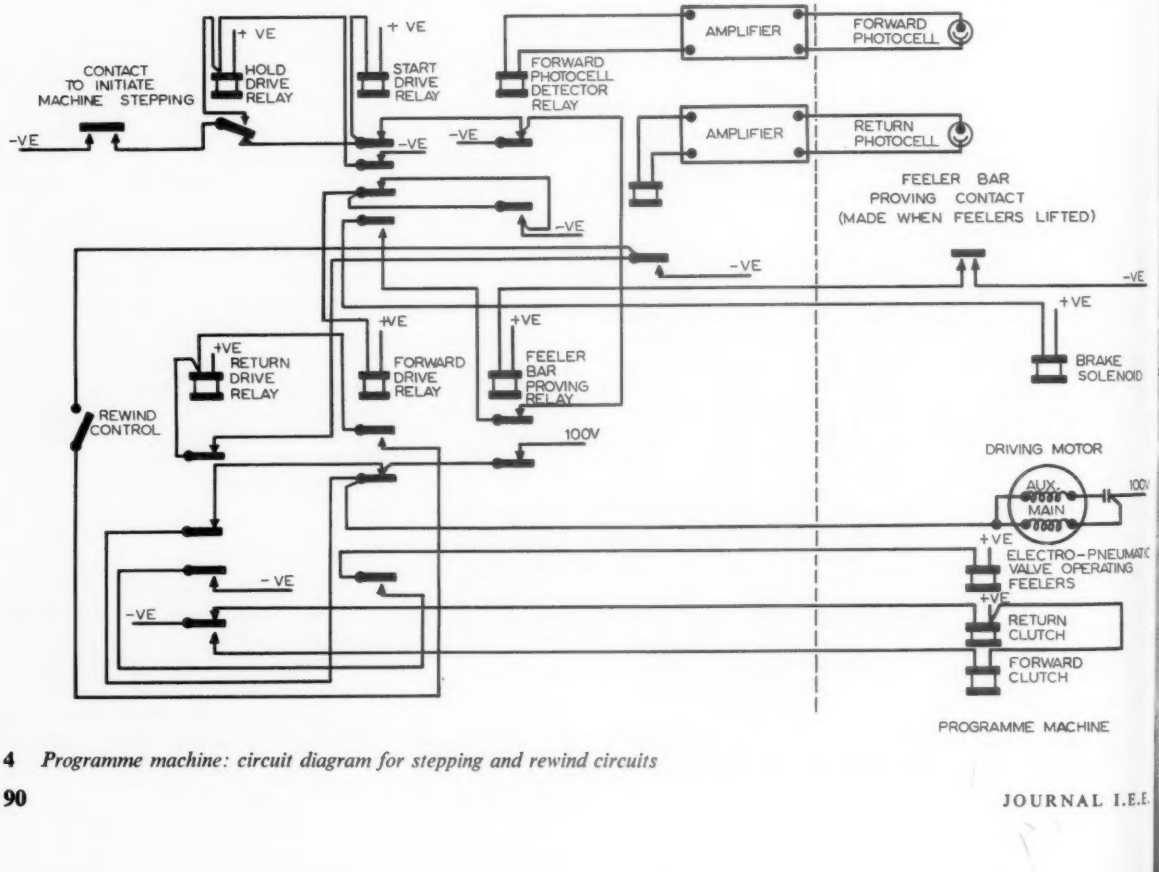
The remainder of the circuit is arranged so that each time the initiating contact on the left is closed the machine steps forward one line of holes on the roll, and when the rewinding contact is closed the machine runs in the reverse direction until it returns to the beginning of the roll.

The programme machines are all identical in construction, but in the installations they are used in two different ways:

As a sequence machine: In this case the machine is arranged to step forward only once for the passage of each train.

As a time-controlled machine: In this arrangement the programme machine is arranged to step forward at predetermined time intervals, and this is done by means of half-minute impulses from an electric master clock. The time interval between each two trains is recorded in binary numerals punched on the roll of the time machine in the form of a number of half-minutes. A relay counter counts the required number of half-minutes from the clock and then steps the machine forward one row of holes.

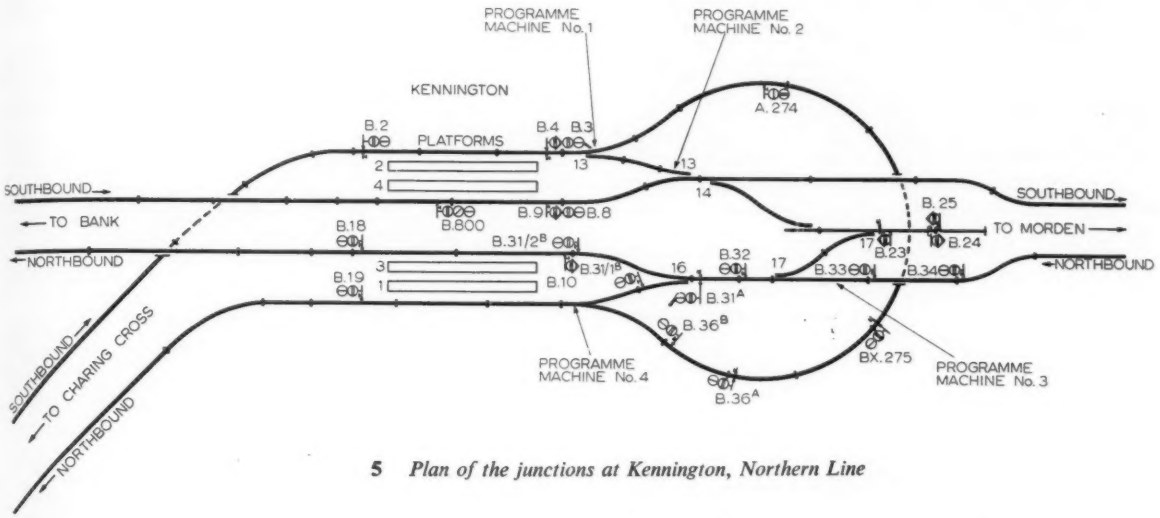
The two forms of operation of the machines are used together in the control of trains over a junction. It is necessary to have a sequence machine which waits for each train and signals it when it arrives, because, if an



4 ***Programme machine: circuit diagram for stepping and rewind circuits***

attempt is made to control a junction entirely from a time-controlled machine, a train that is late is entirely lost by the machine stepping on.

It is, however, required to have reference to the time to check that the service is running in accordance with the time-table and the actual clearing of signals at a given time, when this is appropriate. The time reference is achieved in the circuits by comparing the sequence machine and the time machine by means of a coincidence circuit, using a code of four holes punched on the roll of both machines.



5 *Plan of the junctions at Kennington, Northern Line*

For a large proportion of the time, the sequence machine is one step ahead of the time machine, because the sequence machine is always reading the next train to come, while the time machine reads that train only at the actual time it is due. When the two machines are in step, the coincidence circuits are completed, giving the required information that the train is now due.

Application of programme machines to railway junctions

In arranging the programme machines to control a fairly complex railway junction, such as Kennington (the plan for which is shown in Fig. 5), it is necessary to apportion separate machines to separate parts of the track layout. For this particular track layout, four sequence programme machines are necessary:

Programme machine 1 is associated with the southbound line from Charing Cross and controls trains reversing round the loop, through trains to Morden—this movement requires also permission from programme machine 2, and trains to be routed into the reversing siding.

This machine is arranged to step forward when a train passes signal 3.

Programme machine 2 is associated with the southbound road from Bank and is concerned with trains proceeding direct to Morden or trains to be routed into the reversing siding.

This machine is arranged to step forward when a train passes over the track between points 13 and 14.

Programme machine 3 is associated with the northbound track from Morden and deals with trains from Morden direct into platform 3, with trains from the reversing siding direct into platform 3, and with trains from the main line from Morden and also from the siding into platform 1, with permission from programme machine 4.

This machine is arranged to step forward when a train passes signal 32.

Programme machine 4 is concerned with trains routed through crossover 16 by programme machine 3 and also with trains reversing via the loop.

This machine is arranged to step forward when a train runs into platform 1.

Two time-controlled machines are necessary to co-operate with the four programme machines, each time machine carrying the information required by two of the sequence machines.

Operation of the circuits controlled by the machines

The electrical circuits associated with the programme machines are arranged to perform these functions:

To signal each train in turn over the junction in accordance with the time-table

To check that the train-describer account of the train agrees with the train's destination as shown in the time-table

To check the time of arrival of the train and to sound an alarm if the train is late by more than a predetermined amount

Where trains are to be signalled over a converging junction, in the event of one of the trains being late,

after waiting an appropriate time, to see that the late train does not put in an appearance and to signal the waiting train over the junction out of turn: to store the information that this out-of-turn working has taken place and to return the programme machine into step when the late train has arrived and the service is again in order.

Fig. 6 is a functional diagram of the working of sequence-programme machines 1 and 2 at Kennington, and the plan at the top shows the portion of the track layout covered.

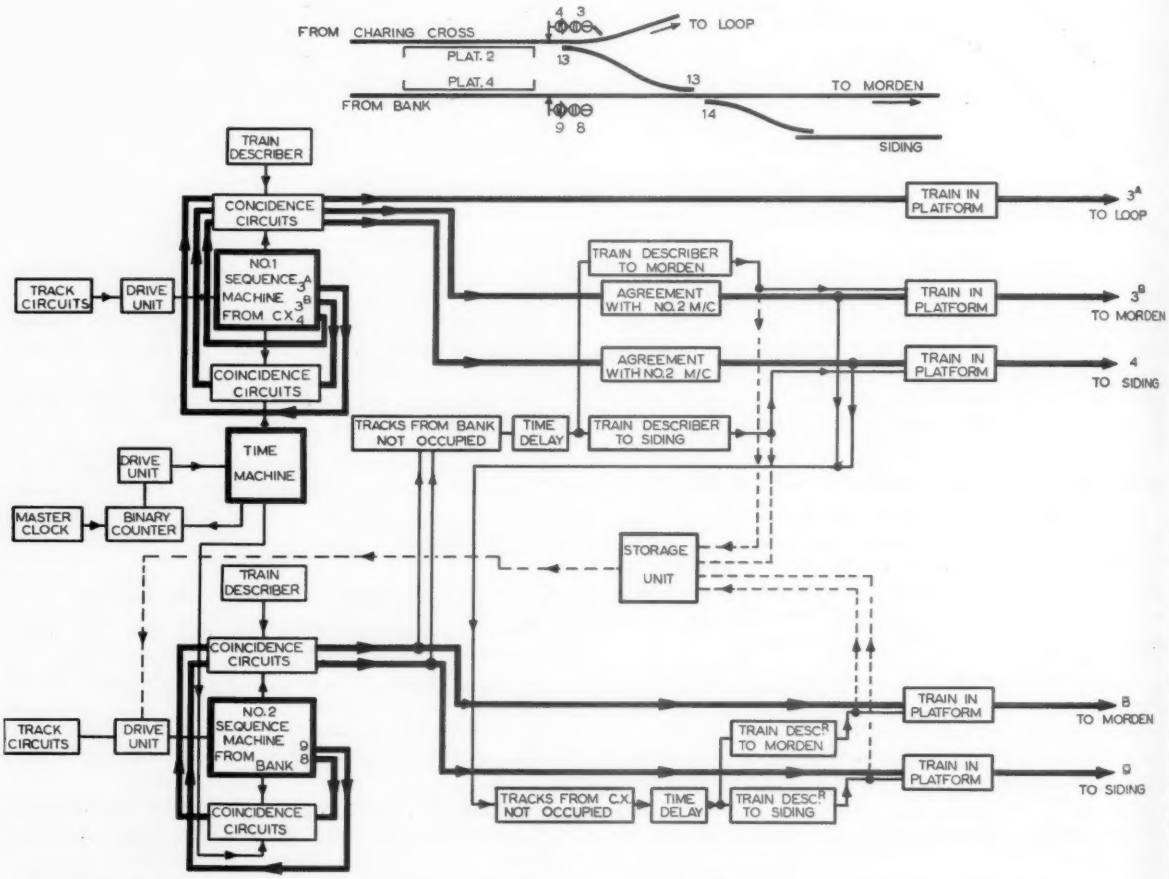
On this diagram, the heavy lines indicate the normal path of control and, following the controls in route 3A for a train from platform 2 to reverse via the loop, the control originates from sequence machine 1. No time control is necessary, but a check of the train describer is required, and this is provided by the coincidence circuit between the train describer and the sequence machine. With these conditions, as soon as the train arrives in the platform the route is set and the signal cleared.

For a train from platform 2 to proceed direct to Morden, the route originates from a different hole in the programme on sequence machine 1, and in this case provision is made for the signal not to clear until it is time for the train to leave, so the path includes the coincidence circuits between the sequence machine and the time-controlled machine.

A check is also made from the train describer by the coincidence circuits, and agreement is now required with sequence machine 2. This is provided by a special punching on the roll of sequence machine 2, and with these conditions fulfilled and the train waiting in the platform the route is set and the signal cleared for the train to proceed to Morden.

Route 4 for a train to the siding originates from sequence machine 1. No time is necessary, but a train-describer check is provided. Agreement is required from programme machine 2. These conditions, with a train at the platform, cause the route to be set to clear signal 4.

The conditions for the remaining two routes from sequence machine 2 follow the same principles.



6 *Functional diagram of programme-machine working of two junctions at Kennington*

Out-of-turn working

As previously mentioned, out-of-turn working is provided to take care automatically of the case of one train approaching a junction being delayed and this not being permitted to delay the whole service. The control paths for this out-of-turn working are shown in the thin continuous lines on Fig. 6.

Taking route 3B, conditions may occur where a train starting from platform 2 is required to go to Morden and should have followed a previous train routed from platform 4, but for some reason the train from Bank has been delayed and has not arrived.

In these conditions, an alternative path is provided from the control path for route 8 just after it leaves the train-describer coincidence. When it is detected that the train has not arrived, although it is time for it to do so, a preset time-delay is started of two or four minutes, according to traffic requirements.

At the end of this time a check is made of the train-describer account, ascertaining that it is, in fact, for a Morden train waiting at platform 2, and these conditions cause the route to be set to clear signal 3B for the route to Morden.

When this alternative condition has been set up, a path to control the stepping forward of the programme machine is completed, shown in dotted lines on the diagram. This path feeds back into a relay storage unit, which stores the information that an out-of-turn movement has taken place and causes these conditions to be observed:

(a) It stops the sequence-machine stepping for the train which has not yet appeared

(b) It stores information of the number of out-of-turn trains that have passed

(c) When the delayed train eventually arrives, it permits the sequence machine, which has been waiting for this train, to step forward, and then causes it to step forward the required additional steps to account for the out-of-turn trains that have already passed. Thus the machine is put back in step with the service.

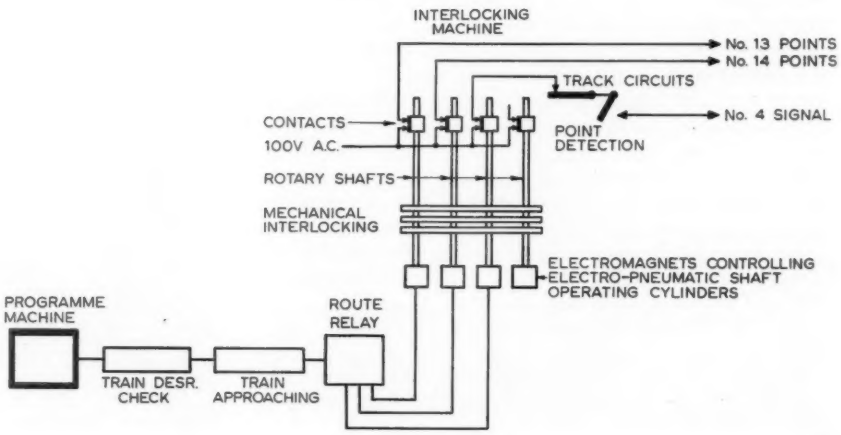
8 *Programme machines and relays controlling the junctions at Camden Town*

All the circuit work associated with the programme machines is on telephone-type relays, the Post Office type 3000 being used. The relays are sealed into clear p.v.c. cases and provided with plug-and-socket connections. The circuits are operated at 50 volts d.c.

Interlocking machine and safety circuits

The outputs from the programme machines and their associated circuits actuate the electro-pneumatic valves for the compressed-air cylinders on the shafts of the interlocking machine, which is retained together with the signalling safety circuits.

The circuits for the actual operation of points and signals start from contacts on the shafts of the interlocking machine and operate at 100 volts a.c. The shafts of the interlocking machine are mechanically interlocked (Fig. 7).



7 *Control of signals and points by programme machine and interlocking machine, showing one route only*

9 *Central supervision room, Leicester Square*

This separation of the circuits into two groups by the interlocking machine is an important feature of the system. It enables the special safety features of the signalling circuits to be fully maintained, while permitting much of the complicated circuit work to be done with relays and wiring not having all the safety features necessary for the signalling proper.

Central supervision room

All the apparatus for the automatic operation of the junctions is located at the sites of the junctions; but to allow supervision of the working, multicore cables are run to a central supervision room, giving information of the working and enabling the operators to make adjustments to the train service, if required. Fig. 8 shows programme machines and some of the relays of the associated circuits used at Camden Town.

A feature of these multicore cables is that a very small conductor, of 0·01 in. diameter, is used. For the purpose required, d.c. operation gives the results wanted, and no very high speed is needed. In these conditions, the impedance of the cable is of little importance, and a saving in cost is achieved.

The supervision room shown in Fig. 9 is provided with this equipment:

An illuminated diagram showing the movement of the trains

Repeaters of each of the sequence programme machines

Provision for cancelling a train shown on any of the programme machines

A set of push buttons to enable the signals and points to be set by hand, if required

Alarms directing attention to these conditions:

(a) A train more than two minutes late
(b) Train describer not correct
(c) Programme machine operating out-of-turn working.

Summary

The installation on the Northern Line demonstrates the possibilities of automatic control of a section of line carrying a very busy service. The programme machine has been designed to be adaptable to meet the conditions required for various parts of the line. The provision of up to 30 holes on each line of the programme enables a very large amount of information to be stored.

A further installation is now in course of construction at the small terminus at Watford. Programme-machine control will be used for: reversing the trains and dispatching them at the correct time; shunting an electric locomotive from one end of the train to the other, when this is necessary; and shunting the trains into sidings at night and bringing them out in the morning.

Power from Loch Shin

THE North of Scotland Hydro-Electric Board have brought into commercial operation the first and most important sections of their Loch Shin scheme—the 3·5 MW Lairg power station and the 24 MW Shin power station, near Inveran.

The two stations make use of the water of Loch Shin, which is controlled by a dam across the narrows west of Lairg. Incorporated in the structure of the dam is Lairg power station.

The water discharged from this station passes into what may now be called Little Loch Shin, the water level of which is maintained by a dam across the River Shin. From the lower dam, the water is diverted through a tunnel to the main station at Inveran, near the mouth of the River Shin. The Shin station has two 12 MW sets.

The Cassley works, which are a further section of the scheme and which will have a power station at the western end of Loch Shin, are still under construction. When completed later this year, this station will have a capacity of 10 MW.

The output of the Shin stations will be fed into the Highland Grid at Inveran and Lairg.

A review of the Proceedings, Parts A and B

SHORT REVIEWS OF PAPERS

ON the following pages are some brief review articles based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers.

Bus electronic scanning indicator

A short article based on a Measurement and Control Section paper (2758) entitled 'Recognition of moving vehicles by electronic means', by T. S. Pick, B.Sc.(Eng.), Member, and A. Readman, Associate Member. Mr. Pick and Mr. Readman are with the London Transport Executive.

A MAJOR problem confronting the London Transport Operating Department is the ever-increasing difficulty of maintaining service regularity of Central London buses against the mounting volumes of traffic and the resulting street congestion.

It is unnecessary to enumerate the difficulties facing the bus-operating staff today, but traffic delays can be divided into two main categories: normal congestion, which results in buses becoming bunched together; and major traffic jams, which cause a complete cessation of movement over considerable periods.

When buses have become bunched, the leading bus is usually carrying more than its quota of passengers and is tending to take longer to unload and load at a bus stop; measures can be taken to pass one of the emptier buses from the rear to the front, the bus times then being more nearly equalized. In a more acute degree of congestion, buses about to enter the congested area may be turned back to fill the gaps caused by the normal service being held up in the opposite direction.

Without an over-all picture of the location of the buses on a route it is difficult to prescribe what remedial measures are suitable; moreover, such measures may have serious repercussions, since bus crews must be relieved at stated periods, either for meals or at the end of their normal turn of duty, and it is essential that the crews running these reliefs correspond to the garage at which the bus ends its schedule.

All the above factors in bus operation can be dealt with if some form of instrument can be produced to signal and record at a central point the identity of each bus as it passes various points not too far apart along the route. This was the problem put to the authors in the summer of 1954, and the outcome is the equipment described as the bus electronic scanning indicator (b.e.s.i.).

The problem for London Transport is to trace some 7000 buses operating on 500 routes. An early estimate was that, over-all, there would be some 200 scanning points, necessitating at least 400 scanning units. The fact that there are 7000 buses makes it clear that the equipment on the bus must be as inexpensive as possible to make a system attractive economically.

With these factors in mind it was finally decided that an optical system would best meet the London Transport needs, but the major difficulties to be solved were, first, to ensure that only the correct light entering the instrument operated the device and, second, that extraneous reflections from other bright surfaces were rejected. A pilot scheme is now operating in London on the No. 74 bus route.

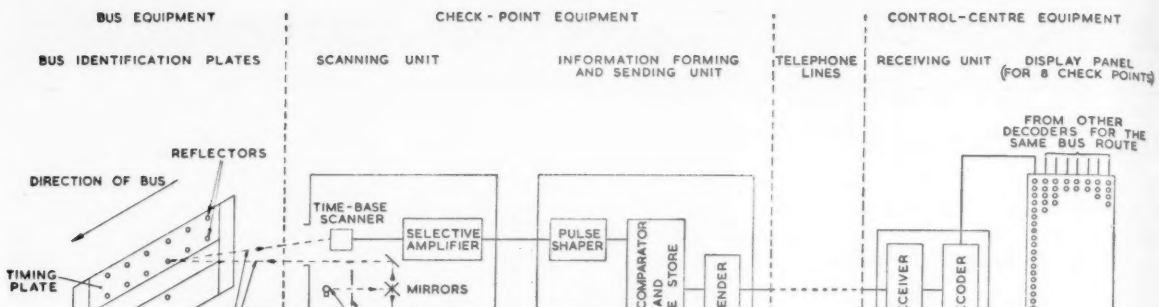
General description

There are five basic types of apparatus forming the system, namely the bus-identification plates mounted on each bus; the scanning unit mounted near the street kerb at each check point; the information forming and sending unit, mounted near to the scanning unit; the receiving unit; and the bus-route display panel. The last two items are housed at the control centre and are connected to the kerbside apparatus by telephone cable.

The system involves a combination of optical and electrical techniques and operates as follows (see Fig. 1).

A light source is mounted in the scanning unit, and the beam, after passing through slots in a rotating disc to give it a distinctive characteristic, is divided by a system of mirrors into two nearly parallel beams and projected on to the bus-identification plates. These consist of an upper plate, with a number of equally spaced reflectors forming the time-base, and a lower identification plate in which the number and position of the reflectors are so arranged as to represent, in binary form, the running number of the bus.

The reflected light is projected back from the upper and lower plates into the scanner through separate windows onto the time-base and code scanners, respectively, where photo-electric cells convert the light into electrical energy. The received light has already been modulated by its passage through the slots of the rotating disc, and the electrical signals accordingly vary at a known frequency, thus enabling the signals to be filtered by selective amplifiers. Any current flowing in the system due to light from other sources is therefore eliminated.



1 *Block diagram of double-beam system*

These signals are passed to the information forming and sending unit, where the pulses are shaped to a suitable waveform for operating valves or relays. By comparing the signals from the timing and code plates, the binary number of the bus can be built up and passed to a code store, where the signals are either stored for later transmission or are routed to the sender for coding and transmission over a pair of ordinary telephone lines.

At the control centre the code pulses are received, decoded and passed to a display panel, where an indication is given of the running number of each bus as it passes the scanning point. The indication is cancelled when the bus reaches the next scanning point on the route, so that each section of the display panel gives the numbers of all buses between any two scanning points. A permanent record may be made.

Bus equipment

The bus equipment in its original form consists of two plates, each fitted with two rows of glass reflectors of the familiar 'cat's eye' type, the lower plate representing the running number of the bus in binary-code form and the upper plate a reference time code to act as a comparator to cancel the effect of variations in the bus speed at the check point.

Particular care was necessary in designing the code plates to ensure successful operation in service conditions and to allow for the many variables which have to be taken into account. As already explained, speed variations of the bus are taken into account by the use of the upper, reference-time-code plate.

The problems of bus loadings and road camber are catered for by the duplication of the reflectors to provide vertical tolerance and by arranging the beam of light to have sufficient vertical depth at the code plate when the bus is at its optimum distance of approximately 12ft from the light source.

The position of the code plates on the bus is selected in such a way that the minimum interference is caused to existing equipment, such as destination blinds and windows; and the height of the code plates above the level of the road is such that other vehicles are unlikely to intercept the beam of light.

Scanning equipment

Scanning equipments are installed at a number of check points along the route. They are positioned at the roadside and mounted at the same height as the bus code plate. The sites are carefully chosen where the road is narrow or at a stopping point, where it is reasonable to expect that the course of the bus will ensure correct alignment of the beam of light and that the interference of other vehicles will be at a minimum. The scanner is sturdy in construction, weatherproofed, and made as light as possible to permit pole-mounting wherever possible.

The double-beam scanning unit is equipped with a light source from a 12-volt 36-watt commercial-type car headlamp. The light source is directed through an optical system onto the periphery of a disc in which are cut 100 slots, and the disc is driven by a motor at 3000r.p.m.; thus the light is modulated at 5kc/s.

The modulated light source is split into two beams of light by mirrors set at right angles. The beams are directed by further mirrors onto the bus code plates, where they are reflected back to the scanner and focused onto two photo-electric cells.

The electrical pulses, which are still modulated at 5kc/s, are passed to resonant amplifiers, which amplify the required signal and reject all extraneous incoming light not originating from the scanner itself. Each

amplifier output is then passed to a full-wave valve rectifier, and the two trains of d.c. pulses of approximately 100 volts amplitude are passed out of the scanner to the information forming and sending unit.

Information forming and sending unit

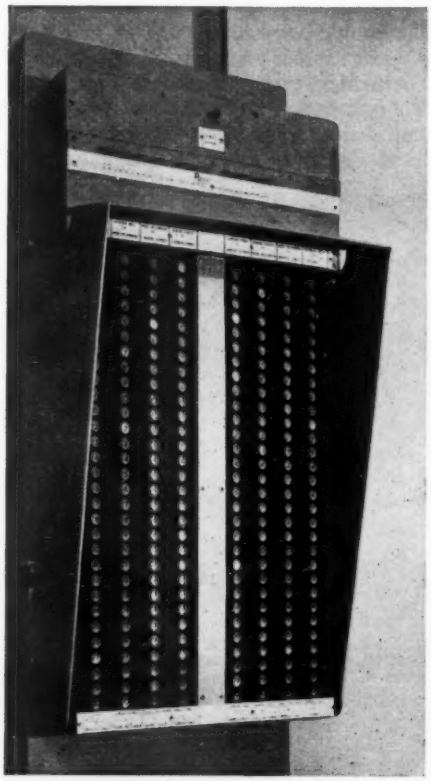
In this unit the 5kc/s modulations are removed, and the pulses, which are approximately sinusoidal, are formed into a square waveform of constant amplitude for driving the subsequent cold-cathode-valve pulse comparator. This consists of two rows of cold-cathode valves, one fired in sequence by the code pulses and the other by time-base triggering pulses. When both the time-base and code valves fire together, Post-Office-type relays are operated in the code store, and a binary number is registered; when only the time-base valve fires, the code-store relay is passed over, and a cipher is indicated.

When the binary number is complete it is ready for transmission over telephone lines to the receiving equipment. The whole of this auxiliary apparatus is contained

2 *Pole-mounted single-beam scanner*

in a weatherproof case, which can be either pole-mounted with the scanner or fitted into a nearby street pillar. Fig. 2 illustrates the pole-mounted single-beam scanner, together with sending units.

Conventional telephone techniques are employed for sending the information over telephone lines to the control-centre equipment. The coded information as transmitted takes the form of a number of positive or negative 50-volt pulses, which are sent in sequence at the rate of about 10 pulses/sec. These pulses are of insufficient magnitude to interfere with normal speech over the same telephone circuit.



3 *The display panel*

Receiver and decoder

Translation of the code at the control centre from binary to decimal notation is obtained on a 'tree'-type relay connection, in which five sets of contacts are arranged to produce a signal in any one of 31 outlets.

At the display panel, each bus is identified by a miniature lamp, on which is shown its running number. The lamps are arranged in vertical rows and are repeated for each scanner position along the route, as illustrated in Fig. 3.

As each bus passes a check point, the position is registered by a lamp in the appropriate display section. This results in an increased voltage drop in the circuit and causes the operating relay of the lamp in the preceding section to become de-energized, thereby cancelling the previous indication.

The display panel thus provides a complete picture of the movements of buses on a particular route and shows at a glance the position and progress of each vehicle as it passes from one control point to the next. Any delays on the route can be instantly recognized, so enabling the traffic controller to take immediate remedial steps.

Recent improvements

Difficulty was experienced in obtaining correct vertical alignment of the double beam onto the two reflectors, owing to the variations in bus loadings and road camber. This resulted in a high proportion of failures. As a consequence, a single-beam scanner using a two-colour system has been developed and is now operating on the No. 74 bus route.

4 *Single bus-code plate*

The double reflector plates on the bus have been replaced by a single code plate, as shown in Fig. 4. The reflectors are arranged in pairs, vertically spaced at 1 in. centres. For the No. 74 bus route, operated by 30 buses, six pairs are fitted horizontally at 2 in. centres to form a compact code plate measuring only 14 × 2 in. The code formation consists of clear reflectors for the units and red for the ciphers of the binary-coded running number.

The receiving optical system in the single-beam scanner is arranged to focus the reflections from the code plate simultaneously onto two colour-discriminating photocells, designated type A and type C. The type-A photocell responds to reflections from the clear reflectors but not to those from the red, and this records the binary-code unit pulses.

The type-C photocell responds to both clear and red reflections and thus records a complete count of all the reflectors in the plate as a timing reference pulse necessary to establish the ciphers in the code. The arrangement thus gives complete synchronism between the code and timing reference on the one code plate, with obvious advantages. The system from here onwards follows the pattern previously described.

Conclusion

Although the apparatus has been specially developed for use by the London Transport Executive for the recognition of moving vehicles from a remote control point, it would appear that the system could be equally well applied, with minor modifications, to the solution of many other similar problems involving the control or recognition of moving objects.

In developing the system for its original purpose of controlling the operation of buses, many variables have had to be taken into account which are peculiar to the detection of free-moving buses. This has imposed limitations in the original equipment which are unlikely to occur in the development of the system for some other purpose. Considerable simplification may be possible in conditions which provide a stricter control of the moving vehicle, such as in recording the movements of vehicles constrained to move on rails.

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Design of the Gas-Filled cable system

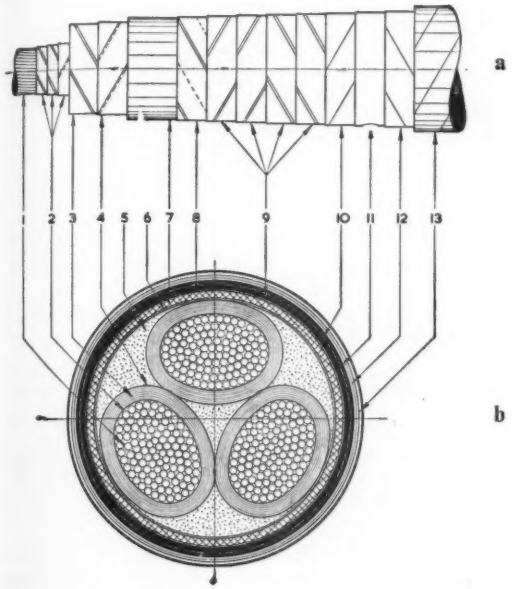
A short review of a Supply Section paper (2754) entitled 'Design and performance of the Gas-Filled cable system', by E. P. G. Thornton and D. H. Booth, B.Sc.(Eng.), Associate Members. The paper was published individually in October 1958 and will be republished in Part A of the Proceedings. The authors are with W. T. Glover and Co. Ltd.

DURING the post-war years, the growth in schemes involving the bulk transmission of electric power at 132 and 275 kV, together with the increasing use of 33 kV as a primary distribution voltage, have given great impetus to the design and development of high-voltage cable systems. Development has been further stimulated by the more recent interest shown in high-voltage submarine-cable schemes for both a.c. and d.c. transmissions.

It was clear in the 1930's that the conventional solid-type cable was not suitable for alternating voltages above 33 kV on both technical and economic grounds. The development of pressure cables for these higher voltages showed that these provided a 33 kV cable system technically

superior and very often cheaper than the equivalent solid-type system. In solid-type cables no positive method of void control is employed, whereas in pressure cables the formation of low-pressure voids is prevented either by introducing oil into the dielectric and maintaining this under pressure by means of auxiliary feed tanks as in the oil-filled cable, or by the use of gas pressure within, or external to, the dielectric as in the gas-pressure cable. Both these methods of void control suppress the ionization that would otherwise occur in the dielectric voids at low pressures and thus permit the use of higher operating stresses, with consequent reduction in dielectric thicknesses.

The Gas-Filled cable, which was first commercially installed in 1937, utilizes nitrogen gas introduced into the dielectric after the cable is laid and jointed. In developing the Gas-Filled cable system, the aim has always been to obtain the economic and technical advantage of a pressure cable system, while keeping its auxiliary equipment as simple as possible. A large measure of this simplicity results from the use of a dielectric made of paper tapes impregnated before lapping. This construction results in a non-draining dielectric which, owing to the absence of surplus impregnant, has pneumatic characteristics that are reproducible under all conditions of installation.



1 *Typical Gas-Filled cables*

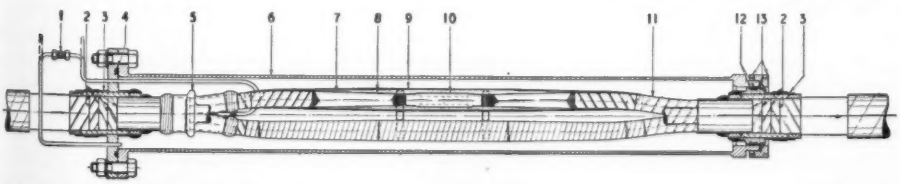
1 Conductor
2 Conductor screen
3 Dielectric
4 Dielectric screen
5 Jute fillers
6 Binder
7 Lead sheath
8 Copper-wire-woven fabric tape
9 Reinforcing tapes
10 Bituminized cotton tape
11 Rubber sheath
12 Carbon-impregnated tape
13 Hessian tapes

a Single-core, 132 kV
b 3-core, 33 kV

Construction

The construction of single-core 132 kV and 3-core 33 kV Gas-Filled cables is shown in Fig. 1. Pre-impregnated paper strips graded in thickness are lapped in air onto a conventionally stranded but screened conductor, the individual cores being screened with copper tape or metallized paper. For 3-core construction, the cores are laid up using pre-impregnated jute strings in the interstices and sheathed with a lead-alloy sheath. For single-core cables with conventionally stranded conductors an annular clearance space is left under the lead-alloy sheath to provide a primary gas-charging channel. On the rare occasions when hollow conductors are used this gas annulus is not required. Sheathing is carried out by means of a vertical lead press fitted with a tray to provide vacuum filling, preventing oxide inclusions at the joint between consecutive charges. The sheath is reinforced with metallic tapes applied at a critical angle to cater for both longitudinal and circumferential components of the hoop stress. In view of the critical mechanical duty of the reinforcement of a pressure cable, these tapes are protected against corrosion by a sheath of vulcanized rubber, which is surrounded by conventional bitumen-compounded textile sheathing for mechanical protection. The cable is not subjected to full nitrogen pressure until after laying and jointing, when, after a gas-tightness test at 250 lb/in.^{2}, the gas is adjusted to the normal operating pressure of 200 lb/in.^{2}

An important section of the paper deals with detailed investigations into the impregnation techniques which were carried out to determine the optimum conditions



2 *Typical 3-core-cable straight-through joint*

1 Mechanical union between gas pipes
2 Reinforcing-tape terminations
3 Cast plumb container
4 O-ring (flange application)
5 Neoprene or p.v.c. breeches-piece
6 Steel sleeve
7 Tapered cable insulation
8 Hand-applied insulation
9 Over-all screening
10 Semi-flush jointing ferrule
11 Screened cable core
12 O-rings (barrel application)
13 Locking and centralizing rings

of operation. The use of models to study the performance of the completed dielectric is also described.

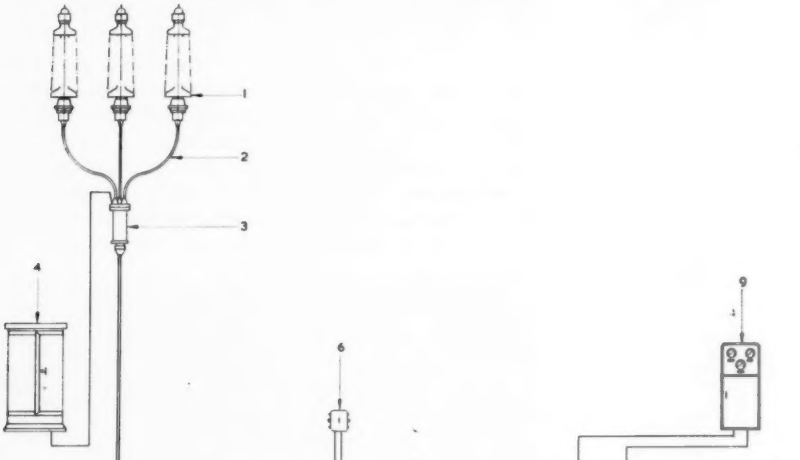
Modern accessories have eliminated the use of elaborate plumbing techniques, and all gas seals are based on the use of synthetic-rubber O-rings. The rings are used in both flange and barrel applications, and a typical straight-through joint is shown in Fig. 2.

A typical arrangement of a Gas-Filled cable system with its associated pneumatic equipment is shown in Fig. 3.

More than 680000yd of the cable are in service, and experience with the system has been most satisfactory. Electrical and mechanical faults have occurred, but their causes are understood and have led to precautions being taken, both in the factory and during installation, to prevent their recurrence.

The system is still in a state of development, and in particular there are interesting possibilities in the use of a combined pre-impregnated-paper and plastic-tape dielectric and also in the use of non-metallic materials as a lead-sheath reinforcement.

The successful service experience and the increasing knowledge of the fundamental behaviour of the system as a whole have confirmed the soundness of the original conception and will undoubtedly lead to further technical and economic improvements. 621.315.211.4



3 *Typical arrangement of 3-core Gas-Filled cable system*

1 Outdoor sealing ends
2 Reinforced lead pipe over cable cores
3 Splitter box
4 Outdoor gas-charging equipment
5 Straight-through joint
6 Intermediate gas-charging box
7 Terminating joint
8 Solid-type single-core cable
9 Indoor gas-charging equipment
10 Customer's switchgear cable box

Arc initiation and power-follow current

A short review of two Supply Section papers (2707 and 2708) entitled 'Impulse initiation of arc discharges', by L. L. Alston, B.Sc.(Eng.), Ph.D., Associate Member, and 'Investigations of power-follow-current phenomena using a synthetic power source', by L. L. Alston and Prof. F. M. Bruce, M.Sc., Ph.D., A.Inst.P., Member. The papers were published individually in November 1958 and will be republished in Part A of the Proceedings. Dr. Alston is with A. Reyrolle and Co. Ltd., and Prof. Bruce is at the Royal College of Science and Technology, Glasgow.

ELECTRICAL breakdown of the insulation on energized high-voltage plant often results in the development of a power arc at the fault, and the term 'power follow' is applied to this phenomenon.

A familiar example is a line insulator which sparks over on the incidence of a voltage surge. If the line is energized at the time, a power-follow arc may form in the path of the spark and develop to carry the fault current of the system at that point. The power-follow arc is not always established, and the initial spark discharge may be self-extinguished so that the system experiences only a transient fault.

It is therefore of considerable importance to know the conditions for the production of a power-follow arc and to be able to check the ability of devices such as rod-gaps or surge absorbers to restrict its development. Similar considerations apply to laboratory techniques in which an arc is initiated by a pulse from a high-voltage source and is maintained subsequently by a separate low-voltage supply.

Experiments on power follow require the availability of a suitable power source and an impulse generator to initiate the breakdown, and the power source is subjected to the impulse voltage applied to the gap or other device on which the experiment is carried out. The circuit used

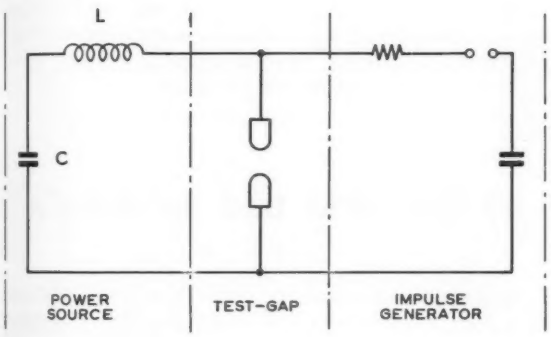
for the present investigation is shown in Fig. 1, in which the inductor L and capacitor C constitute a 'synthetic' power source and the high-voltage pulse is derived from a Marx impulse generator. Two main advantages ensue from the use of a synthetic source. First, variables are easily controlled; for example, the frequency $[1/2\pi\sqrt{(LC)}]$ and output impedance $[\sqrt{(L/C)}]$ can be varied over a wide range by altering L and C. Secondly, insulation problems are restricted to the inductor. When the inductance was large it was built in two units, and a non-ohmic resistor was connected between their junction and earth so that only one unit had to withstand the impulse voltage.

Energy was stored in the power circuit before flashover by charging its capacitor to a voltage V_0; this corresponded to the peak voltage of the system represented. When a power arc developed, the stored energy was dissipated in time through losses in the circuit and arc resistance.

This, apparently serious, limitation was overcome by defining power follow as the development of a discharge with arc characteristics sustained by current drawn from the source and lasting until the first current zero of the oscillatory power source. The justification for this was evidence that low currents (of about 1 amp) would give an arc characteristic. Once this has been established, transition to an arc is complete, the subsequent arc current in a practical case being limited only by the impedance of the system.

Experimental details

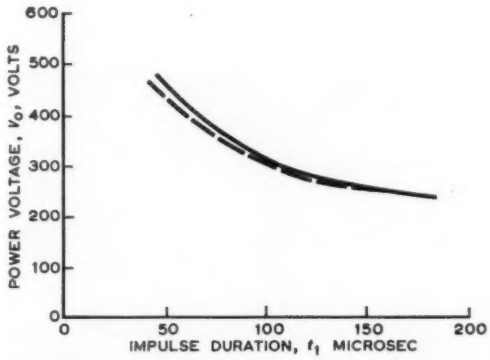
Experiments were carried out on gaps of 0·05 to 10 cm, using impulse voltages and currents up to 200 kV and 600 amp and power voltages and currents up to 2·5 kV and 600 amp. The power frequency was usually



1 *Circuit diagram*

50 c/s, but values up to 500 c/s were used, and the duration of the impulse discharge varied between 50 and 2000 microsec in different experiments. Instantaneous values of power current, discharge current, voltage, power input and effective resistance were obtained from oscillograms; and from these data it has been possible to assess the effects of impulse, power-circuit and electrode parameters.

Impulse effects have been separated into those associated with the voltage or the current waveform. In addition to producing the flashover, the impulse voltage



2 *Relation between impulse duration and the power voltage required for power follow*

The solid curve was obtained from an experiment on a 0·5 cm gap, at 50 c/s. The broken curve was obtained from $V_0 \propto 1/t_1$

circulates a current in the power circuit during the time-to-flashover of the test-gap. At flashover, that current has the value I_0, which approximates to:

$$\frac{\text{(impulse voltage)} \times \text{(time to flashover)}}{\text{circuit inductance}}$$

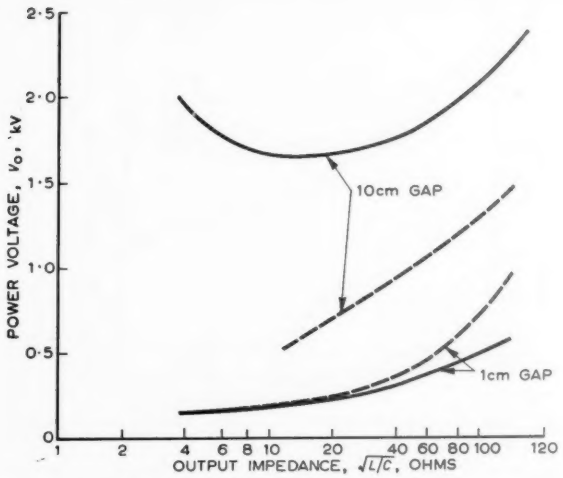
and after flashover the power current builds up from that value. If the power and impulse voltages are of the same polarity to earth, I_0 is in effect negative and opposes the establishment of power follow; the reverse occurs if the two voltages are of opposite polarity to earth.

After flashover, the important impulse characteristic is the duration of current flow, since power current builds up while conduction in the discharge-gap is maintained by the impulse. Consequently, the longer the duration of flow of impulse current, the smaller the value of V_0 required for power follow; and this is illustrated in Fig. 2, which was obtained from an experiment in which the impulse and power voltages were of the same polarity to earth.

Certain characteristic phenomena were observed in this and other experiments in which the impulse duration was small compared with the period of the power circuit, and this led to the definition of a type of power follow which was designated 'high-voltage follow current'. Its main characteristics were that power follow occurred if the power current exceeded a value of the order of 1 amp, and this required a value for V_0 which was large compared with an arc voltage; when power follow did not occur, the test-gap deionized within a time of the order of 100 microsec from the end of the impulse.

Glow–arc transitions were recorded frequently during the immediate post-impulse period and led to the

deduction of a criterion for arc initiation. This states that if the power circuit supplies a current I_{t1} at the end of the impulse, a power arc will be established provided



3 *Relations between the output impedance of the power circuit and the power voltage required for power follow*

—— Impulse and power voltages of same polarity
— — Impulse and power voltages of opposite polarity
Power frequency was 50 c/s, and the impulse duration was 220 microsec

that V_0 exceeds a value approximately equal to that required to maintain a glow discharge in the test-gap in steady-state conditions, at a current not greater than I_{t1}.

When the impulse duration exceeded $\pi\sqrt{(LC)}/8$ (i.e. 1·2 millisec for 50 c/s), different phenomena were observed, and these led to the definition of high follow current. Its main characteristics were that, when power follow was established, the power current was sufficiently large to maintain a stable arc after the end of the impulse, and V_0 was of the order of an arc voltage; current could flow for a considerable time after the end of the impulse even if power follow did not occur. The dependence of V_0 on impulse duration was much smaller than for high-voltage follow current.

When the power and impulse voltages are of opposite polarity, a current zero occurs in the test-gap towards the end of the impulse, so that power follow can only occur after a restrike. On these grounds alone, arc initiation is less likely than when the two voltages are of the same polarity, but additional factors have to be considered, notably the current I_0. Thus for Fig. 3, the time-to-flashover was relatively long for the 10 cm gap; I_0 was therefore large, and power follow was established more readily when the two voltages were of opposite polarities. The reverse happened for the 1 cm gap, for which I_0 was negligible.

Electrode material

The effects of electrode material, shape and surface condition were studied in detail for gaps up to 1·5 cm; at higher spacings these effects were not significant. Agreement was obtained with other workers who had studied glow–arc transitions in steady-state conditions, in that oxidation and roughening of the electrode material facilitated arc initiation. An exception was recorded with aluminium electrodes, in which oxidation and roughening increased the time-to-flashover and prevented arc initiation in certain conditions.

To sum up: the mechanism of power follow has been explained, and two types (high-voltage and high-current) have been identified. Data have been obtained on glow-arc transitions in transient conditions, and a criterion has been derived for the initiation of power arcs. It has been shown that power follow becomes established at currents of the order of 1 amp, so that power-follow phenomena, including those in large gaps and at high power voltages, can be studied in the laboratory, using a power source capable of providing currents of this order.

621.387: 621.316.933: 621.317.333.8

Power/frequency characteristics of the Grid and automatic frequency control

This is a combined review of a Supply Section paper (2790) entitled 'Power/frequency characteristics of the British Grid system', by M. Davies, M.Sc., Ph.D., F. Moran, M.Sc., and J. I. Bird, Associate Member, and of a Measurement and Control Section paper (2781) entitled 'Power-system automatic frequency control techniques', by F. Moran. The two papers were published individually in November 1958, and they will be republished in Part A of the Proceedings. The authors are at the Central Electricity Research Laboratories.

THE planning of the interconnection between the French and British power systems presented many new and interesting technical problems. Not least of these was the feasibility of operating two large systems in parallel via a relatively slender link if an a.c. cable were used. It was concluded that such a scheme would be practicable if automatic regulation were installed in Britain, and this in turn led to the development of experimental prototype equipment.

In any power system the impracticability of making the generation follow exactly the fluctuations in demand results in small alterations in the system frequency. This effect may be expressed by the elementary equation $\Delta P + K\Delta f = 0$, where ΔP is a small change in power (load or generation) and Δf the corresponding change in frequency. The parameter K, which depends on the plant/load conditions, is termed the power/frequency characteristic of the system.

When two systems A and B are interconnected, a power disturbance in either system results in a small variation in the common frequency, which the turbine governors tend to correct according to their respective regulation characteristics. This results in power fluctuations in the interconnector which correspond to the permanent equalization of the two system frequencies.

A simple relation connects the change ΔP_i in the power transfer in the interconnector and the change in the difference Δf_{A-B} between the frequencies of the two systems if the same disturbance is applied with the systems disconnected, namely:

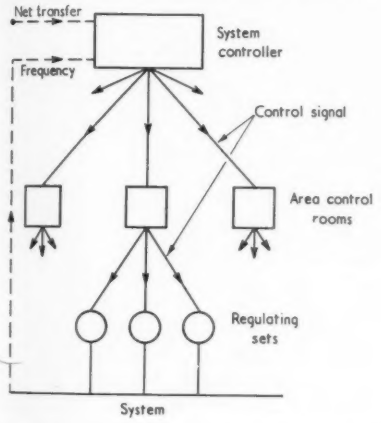
$$\frac{\Delta P_i}{\Delta f_{A-B}} = \frac{K_A K_B}{K_A + K_B} = \gamma, \text{ say,}$$

where K_A, K_B are the power/frequency characteristics of the two systems.

Hence if the values of K for the British and French systems are known, the power-transfer fluctuations on a hypothetical a.c. link can be deduced from measurements of the simultaneous frequency difference between the two systems.

Automatic frequency control

To evaluate the power/frequency characteristic of the British system it was necessary to produce a known disturbance of about 150 MW for the corresponding change in frequency to be measurable. This was done by simultaneously tripping three 50 MW steam-operated generators at Hams Hall 'B' power station. Because of the operational difficulties



1 *Schematic of control scheme developed for British system*

involved, only three such tests were made, and in the majority of cases the expedient of carrying out line-trips was used.

For the line-tripping tests, the north and south of the country were interconnected by a single line in the Midlands, a transfer of 100–170 MW was established and the line was tripped.

K was found to vary between 2000 and 5500 MW per c/s, according to plant and load conditions. This means that a 0·1 c/s change in system frequency would result from a disturbance of between 200 and 550 MW.

From a study of the mechanics of governor action, the results of the tests enabled the following estimating equation for K to be derived for the British system:

$$K = 0{\cdot}8P_T - 0{\cdot}6P_L$$

where P_T and P_L are respectively the total rated turbine capacity on the busbars and the load.

The validity of the relationship between frequency difference

2 *System controller, showing computing equipment on left and frequency standard on right*

and power transfer on an interconnector in actual operating conditions could be checked only statistically, because of the impossibility of operating two systems interconnected and independently at the same instant. Duration tests were therefore carried out with the same system arrangements as for the line-tripping tests, the two sections of the country being operated with the interconnector first closed and then opened.

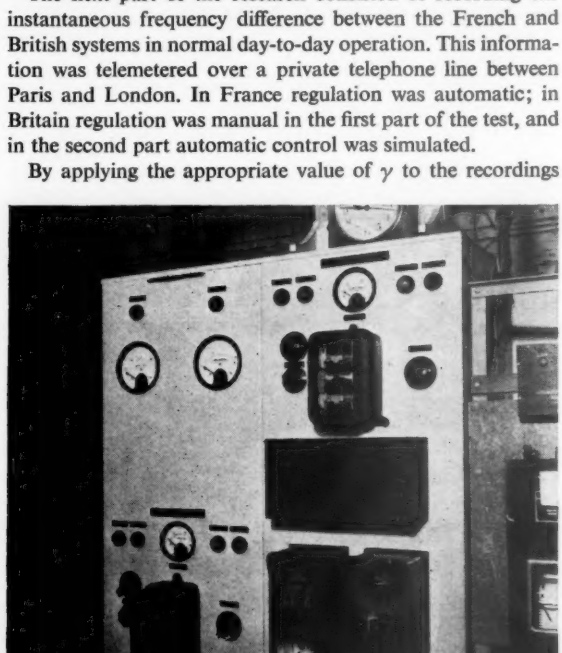
The ratio of the standard deviations of power transfer and frequency difference in the two parts of the test should theoretically be equal to γ, and this was found to be so for short periods or when the effects of manual control were eliminated.

Tests similar to those described above were carried out in France.

Programmed transfers

The next part of the research consisted of recording the instantaneous frequency difference between the French and British systems in normal day-to-day operation. This information was telemetered over a private telephone line between Paris and London. In France regulation was automatic; in Britain regulation was manual in the first part of the test, and in the second part automatic control was simulated.

By applying the appropriate value of γ to the recordings



3 *Front view of the two turbine regulators*

of frequency difference, the power fluctuations which would have occurred on an interconnector joining France and Britain were derived. In order to estimate the temperature rise which would have occurred in the cable, these power fluctuations were superimposed on various programmed transfers and a current proportional to the power flow fed into a thermal image of a 132kV cable.

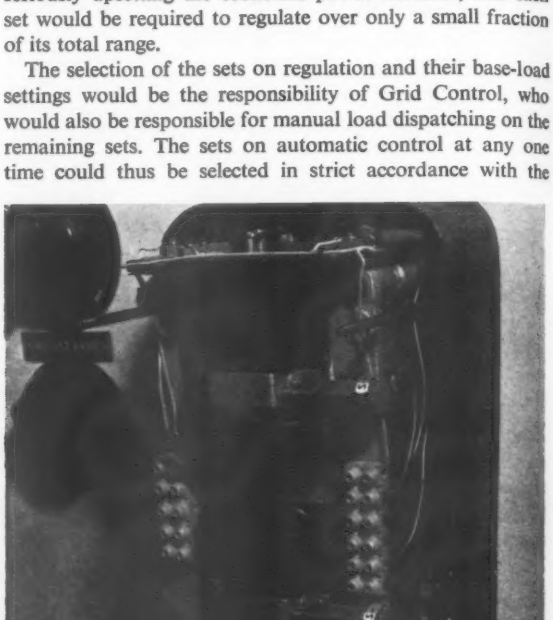
It was concluded that a programmed transfer of 150MW on a cable of 200MVA capacity would be feasible provided that a standard of frequency control at least as good as that realized during the tests were maintained. For this purpose, automatic regulation would have to be installed in Britain.

The alternative of a d.c. cable scheme which has since been adopted has made this requirement less urgent, but the need for automatic control may emerge again as the system develops, and in such an event the experience gained in this field will be invaluable.

Proposed scheme of automatic control

It was realized at an early stage that in a system as large as the British the regulating burden would have to be spread over a large number of generating sets. The main reasons for this were that it would then be possible to regulate without seriously upsetting the economic power transfers, and each set would be required to regulate over only a small fraction of its total range.

The selection of the sets on regulation and their base-load settings would be the responsibility of Grid Control, who would also be responsible for manual load dispatching on the remaining sets. The sets on automatic control at any one time could thus be selected in strict accordance with the



4 *Close-up of the sensitive element in a turbine regulator that balances the output of the set against the desired level of generation*

requirement to load plant in economic order of merit, within the limits of the transmission capacity of the system.

Communication

One of the major problems in carrying out the simultaneous and co-ordinated regulation of a large number of sets is that of communication. In order to reduce the communication requirement to a minimum, a scheme was needed in which

information would be passed only from the control centre to the regulating sets and none in the opposite direction. This is a disadvantage with many existing forms of control.

The primary element in the scheme evolved (see Fig. 1) to comply with the above requirements is a system controller that computes continuously the regulation required. A control signal proportional to the regulation is transmitted to the Grid Control Centres, where it is routed to those generating sets required to participate in the regulation. The turbine regulator of each set on automatic control so balances the output of the set against the control signal as to cause it to contribute the proportion of its individual range of regulation called for by the control signal. This contribution is additional to its base loading.

Any failures of sets to implement fully their regulation requirement result in further demands from the master controller until the necessary regulation is achieved. In order to reduce the regulating action to a minimum, the master controller may be arranged to change the control signal in discrete steps at definite intervals of, say, a minute; alternatively, continuous correction may be applied.

The system controller shown in Fig. 2 computes the required regulation from the frequency and transfer errors and can also be made to take account of the rates of change, as well as the first and second integrals of these quantities, in order to improve the quality of control. This system controller and two turbine regulators, shown in Figs. 3 and 4, were used to control a small isolated system in tests of the control scheme, and very satisfactory results were obtained.

621.311.161 : 621.316.726

SYNOPSES OF PAPERS

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available shortly.

Transistors in phase-comparison carrier protection

A synopsis of a Measurement and Control Section paper (2793) entitled 'Application of transistors to phase-comparison carrier protection', by Colin Adamson, M.Sc.(Eng.), Associate Member, and E. A. Talkhan, B.Sc. The paper is published this month in Part A of the Proceedings. The authors are in the Power Systems Laboratory, Department of Electrical Engineering, Manchester College of Science and Technology.

THE paper shows the potentialities of the junction transistor when applied to phase-comparison carrier protection and the flexibility of transistor circuits for the effective performance of a number of different relaying functions. High-frequency high-power transistors, which are now available, make it possible to obtain the required level of carrier output power.

The paper also deals with the general aspects of a phase-comparison carrier system of protection. The most important of these aspects are the choice of the relaying quantities and the effect of load current on the phase representing quantity, with its consequent effect on the minimum possible settings for earth faults. A sequence network is described which produces all the relaying quantities simultaneously, using only three main current transformers. The effect on the relaying system of a d.c. transient component in the fault current is analysed; a filter network is used to eliminate the d.c. transient and harmonic components, thereby producing uniform performance in differing fault conditions.

Two successive equipments have been built and tested in steady-state and transient conditions. The transient-tests result of the final equipment are given. Since the transistor is temperature-sensitive, exhaustive temperature tests were made.

621.316.925 : 621.315.052.63 : 621.382

Rotor leakage reactance and resistance of 3-phase induction motor

A synopsis of a Utilization Section paper (2757) entitled 'A new method of determining rotor leakage reactance and resistance of a three-phase induction motor', by Prof. M. V. Deshpande, B.E., M.S., Member, and T. R. Subrahmanyan, B.E., M.E., Student. The paper is published this month in Part A of the Proceedings.

The authors were at the L.D. College of Engineering, Ahmedabad, India, when this work was done in 1956–57. Prof. Deshpande is at present at the University of Illinois, on a visiting appointment.

THE paper develops a new method of determining the rotor leakage reactance and resistance of a 3-phase induction motor.

Stationary flux distribution of constant magnitude is produced in the air-gap of the machine by supplying direct current to the stator windings. The rotor is driven at various slip speeds simulating the conditions of a 3-phase induction motor. The power input to the rotor is measured. The flux distribution in the stator teeth per pole pitch is measured by use of search coils and a ballistic galvanometer when d.c. excitation to all three phases of the stator is suddenly removed. The voltage induced per phase in the stator owing to this change of flux linkage is calculated. An expression is developed for rotor leakage reactance and resistance.

The theory is proved by experimental work. The performance is calculated, using the rotor constants measured by this method, and is compared with that obtained by no-load and locked-rotor tests and by an actual load test. A comparison of results justifies the determination of rotor constants by this new method.

621.313.333.2

CORRESPONDENCE

THE JUNCTION TRANSISTOR AND ITS APPLICATION

From E. WOLFENDALE, B.SC.(ENG.), ASSOCIATE MEMBER

WHEN writing an article which sets out to explain a rather complex subject in simple terms, the major problem is to know where to start. If one goes too far back in one's explanations, the simple article becomes complex by its detail; but if one leaves out too much, the simple article becomes complex by its brevity. The latter would appear to be the case here; and I would therefore like to thank Mr. Robinson for his letter (January *Journal*, p. 30), as he has given me the opportunity to delve a little deeper into the subject.

First of all the carrier. In the past, the electron has been considered the only carrier of electric charge, in fact a negative charge; but does anyone know what an electron really is?

You will certainly get different answers from an engineer and from a physicist. One will perhaps describe it as a negative charge, and the other perhaps will describe it in terms of wave mechanics. The concept of an electron has been a convenient representation of the charge carrier for conventional electronics, and I emphasize the word representation.

Unfortunately, when we come to solid-state devices like the transistor we find that the electron or negative carrier is not sufficient; there are other carriers of positive charge, and so we introduce another representation, the hole. Again let me stress the word representation: the hole and the electron represent carriers of positive and negative charge respectively and give us a simple mental picture of the inner workings of a transistor. If we like we can dig deeper into the physics, but this will only complicate our simple picture. The engineer dealing with solid-state devices like the transistor need not dig deeper: he need only accept on trust, just as he accepted the electron on trust, a new carrier of positive electricity, the hole.

Now we come to the current flow from the battery to the emitter, holes across the emitter junction to the base, etc. The difficulty here in the explanation is that we cannot apply our new conception of the hole to the long-established explanation of the battery. Holes cannot flow from the positive of the battery, electrons have to flow to the positive of the battery. Where do they come from?

In the simple explanation no mention is made of how the connections are made to the emitter base and collector of the transistor. In practice, a contact made between a metal conductor and a semiconductor can be a rectifying contact unless it is made in a special way, when it becomes an ohmic contact. An ohmic contact is defined as a contact which is an excellent recombination centre at which holes and electrons are continuously being generated and continuously being recombined.

Therefore, when holes leave the ohmic contact to move across the emitter to the base, electrons are left which would have recombined with these holes; and these electrons move into the conductor, and the conductor supplies electrons to the positive of the battery. To give a fuller explanation would require the use of Fermi levels and the energy band structure at the surface of a semiconductor, and again I think the engineer would be advised to take on trust the definition of an ohmic contact.

To answer Mr. Robinson's other questions: Negative free carriers, electrons and negative electrons are one and the same, as are positive free carriers, holes and positive holes. The words 'negative' and 'positive' in connection with electrons and holes should be omitted in future. They were used in my article to emphasize the respective charges of these two carriers. Pure germanium contains very few free carriers, but the free carriers that are present are both holes and electrons.

From H. R. WESTAWAY, ASSOCIATE MEMBER

THERE is a minor point in the article by Mr. E. Wolfendale (November *Journal*, p. 583) to which I would refer since it gives me an opportunity to express a personal opinion on a matter of terminology.

On p. 586 the author refers, incorrectly in my submission, to an arrangement of resistors for providing base bias to a transistor as a 'potentiometer'. Later on the same page he calls this arrangement, correctly, a potential divider.

I am only too well aware of the convention in this respect and of the fact that opposition to it is on a par with the efforts of King Canute but nevertheless feel that, since a potentiometer is in fact an instrument for the measurement of potential difference, the common use of the term to describe an uncalibrated potential divider is regrettable.

WORDS, WORDS, WORDS

From C. S. JEFFREY, MEMBER

'WHEN *I* use a word', said Humpty Dumpty, 'it means just what I choose it to mean—neither more nor less.'

I open up my monthly JOTI
And read of DIDO and of ZEUS.
I learn, and fog my ancient cranium,
With words like TASI and germanium.
I see newfangled words in shoals
And grieve transistors have but 'holes'.
May I address our worthy POTI,
Per medium of his faithful SOTI,
And ask should he, or didn't ought he,
Permit of language such abuse.
Or must I nurse but vain regrets
That Scotsmen should be known as SETS.
I am obsessed by horrid thoughts
We'll have a column-heading BOTS
(p. 632, November).

We are often reminded that our language is a living thing and must grow, but it need not grow like a weed. The *Journal*

is one of the few publications which posterity will value. May I suggest that new words should pass an entrance examination before admission to The Institution. My B.S. Glossary of Terms is now old. May I ask what happens when a new word is born? Is there a child-welfare organization to care for it—or strangle it?

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

JOHN HENRY ASDELL

John Henry Asdell, M.SC., died while on holiday in Hampshire on the 29th July 1958. He was born on the 13th February 1889 and attended King's School, Chester, where he showed a special aptitude for mathematics, being placed second in the country in his Cambridge Local Examination. In 1905 he went to Birmingham University, where he graduated and as a Bowden Scholar spent a year in postgraduate studies gaining the M.Sc. degree.

He then joined his father in the London and North Western Railway Engineering Department and was concerned with some early electrification work. However, illumination was his special interest, and he joined the British Thomson-Houston Co. Ltd., Rugby, to gain experience in this field.

At the beginning of the 1914–18 War he was granted a commission in the Royal Naval Volunteer Reserve, only to be rejected because of a heart weakness which restricted his physical activities for the rest of his life. He served with the Ministry of Munitions instead and later with the Edison Swan Electric Co., London.

In 1922 he commenced an agency business and became manager for A. D. Lang Ltd., London; but three years later he joined Parker, Winder, and Achurch Ltd., Birmingham. He went into practice in 1939 as a consulting engineer, carrying out many illumination schemes for cinemas, commercial buildings and factories. He joined Tube Investments Ltd. in 1940, dealing with the equipment of new plants for shell production, and he remained as chief electrical engineer of T.I. (Group Services) until his retirement.

Asdell was particularly interested in the Birmingham Electric Club, which he joined in 1925 and served successively as secretary, vice-president and president, becoming secretary again from 1939 to 1947. He always took a great interest in technical and general education. He was a member of the Court of Governors of Birmingham University, of the Electrical Advisory Committee of the College of Technology, and, later, of a similar committee for the other Birmingham technical colleges.

Caravaning was his chief hobby, and he was a keen member of the Caravan Club. He died in his caravan at Solent Breezes. He is survived by his widow and a son and a daughter, both married.

He joined The Institution as an Associate Member in 1947 and was elected a Member in 1949. He served on the South Midland Centre Committee from 1947 to 1950. A. M. F.

EDWARD ARTHUR BARKER

Major Edward Arthur Barker, M.C., who died on the 3rd July 1958, was born on the 13th October 1877. He was educated at King Edward's High School and the Technical College, Birmingham, followed by a five-year apprenticeship with the Walsall Electrical Co.

He became a junior assistant with the company in 1898 and a year later transferred to the Hull Corporation Electricity Department. In 1900 he commenced duties as chief assistant engineer with the Barnsley Corporation Electricity Undertaking and, in 1903, was appointed borough electrical engineer, a post which he held until his retirement in 1946.

He served throughout the First World War with the York and Lancaster Regiment and later with the Royal Engineers at G.H.Q. Wireless Section, Woolwich.

Barker was well known throughout the electricity supply industry and served on several national committees. For many years he served on the Council of the Incorporated Municipal Electrical Association and also on the Executive of the Association of Municipal Electrical Engineers, being honorary treasurer for 23 years.

He is survived by his daughter, Mrs. H. Slack.

He joined The Institution as an Associate in 1900 and was elected an Associate Member in 1902 and a Member in 1909. He served on the Yorkshire Committee in 1910 and from 1914 to 1915. He was vice-chairman of the North Midland Centre in 1921 and 1923. J. H. N.

MAURICE MAYHEW BEAR

Maurice Mayhew Bear, who died on the 22nd August 1958 at his home at Wincanton, was born at Thorpe, Essex, on the 2nd August 1871. He was educated at the City of London School and at Finsbury Technical College. He served a four-year apprenticeship with Davey Paximan and Co., Colchester, and gained further works experience with Hawthorn Leslie and Co. and elsewhere from 1893 to 1896 before joining Thorsten Nordenfelt as a representative.

He was appointed general manager of Holden and Brooke Ltd., Manchester, in 1900, with whom he obtained a wide experience in general engineering and particularly in the construction and operation of cylindrical boilers. In 1903 he accepted a position with Babcock and Wilcox Ltd., London, subsequently transferring to Manchester, where he held several responsible positions. In 1910 he was invited to establish the company's interests in India, and he entered on this task with his wonted enthusiasm, founding the head office in Calcutta.

Bear's disposition and charm of manner enabled him to make friends wherever he went, and he coupled this with integrity and ability. The incidence of the First World War curtailed activities in so far as new plant was concerned. However, his efforts to meet the most pressing demands were generally successful, by improvisation and the revitalizing of old, and often outmoded, equipment. At the end of the war, the steam needs of the Subcontinent were catered for to a very large extent by him and his considerable organization throughout India and Burma.

During his period in India he was closely identified with the formation of the Institution of Engineers (India), serving on the Council in 1920–21, and he was a prominent member of the Bengal and other clubs in Calcutta. He returned to England in 1922, and for ten years his services were in demand for consultation and guidance. During this time he paid several visits to India.

He gained the loyalty and affection of every man in his employ, both European and Indian. The first inquiry of any who had known him was for the welfare of their old friend. In his retirement he assisted his wife, who predeceased him, in the running of an evening social club in London, catering for young peoples' occupation and entertainment. He could always be relied on for entertainment with his banjo. These activities they continued throughout the Second World War.

He joined The Institution as an Associate in 1909 and was elected a Member in 1921. He was also a Member of The Institution of Mechanical Engineers. A. L. V. L.

HAROLD HODGKINSON BROUGHTON

Harold Hodgkinson Broughton, who died on the 3rd June 1958, was born in 1882 and was well known as a consultant on the electrical handling of materials. He was educated at Huddersfield Technical College and apprenticed to Kitson and Co. and Messrs. Broadbent. He was awarded a Whitworth Exhibition in 1904.

He joined the staff of Brighton Technical College in 1903 and became a member of the editorial staff of *The Electrician*, now the *Electrical Journal*, in 1915. In his work as a teacher he brought a sound knowledge of mechanical and electrical engineering before his students, who had the benefit of his meticulous attention to detail and the inspiration of hard work at a time when technical teaching was both arduous and not highly remunerative. He liked to start off his tutorial sheets with a relevant quotation from the classics. One of these quotations was Carlyle's 'Work is for the living', and it was reported in the local Press that some wag among the students had added 'O Death, where is thy sting'.

In 1916 he was appointed chief engineer in the electrical department of Vickers Ltd., London, and spent three years as resident engineer in Canada for the company from 1923. Returning to England, he became engaged in consulting-engineering work on his own account, first with Preston Bros., Hull, and then with Aire and Calder Navigation, Leeds, and made the electrical handling of materials his lifelong study.

For 30 years he was actively associated with the British Standards Institution on numerous British Standards for cranes. The third edition of his monumental work 'Electric cranes' was published in 1958, having first appeared in 1911; other books were 'Electric winders' and 'The electrical handling of materials'. At one time he was a keen philatelist and took a great interest in the stamps of China.

Beneath a forthright manner was a kindly nature, always willing and eager to help those seeking knowledge who were prepared to work on their own account. Many engineers have much to thank him for in their early years of training. He will be greatly missed for his practical experience and specialized knowledge.

Broughton joined The Institution as an Associate Member in 1906 and was elected a Member in 1912. He was also a Member of The Institutions of Civil and of Mechanical Engineers. J. E. M.

SIDNEY ERNEST THACKER EWING

Sidney Ernest Thacker Ewing, who died on the 12th June 1958, was born in Calcutta in 1876. He was educated in England at Dulwich College and at Faraday House.

After working in England for four years, he emigrated to Southern Rhodesia in 1900 to become chief electrical engineer of Rezende Ltd., a gold-mining company.

Before the First World War, Ewing joined Brakpan Mines Ltd. in the Transvaal as electrical engineer. He was eventually appointed consulting mechanical and electrical engineer of the Anglo-American Corporation of South Africa, which position he held until his retirement in 1939. He was responsible for the design and construction of the treatment plants on many gold mines developed on the East Rand by the Corporation. During this period many outstanding technical advances in gold recovery were pioneered by him, the principles of which are standard practice today in the gold-mining industry as a whole. He also carried out much pioneering work on the cooling of mines.

Ewing was of a retiring disposition and entered little into social activities. He was a sound judge of men, was decisive and forthright in business, and was respected by all with whom he came into contact. His passing will be mourned by his colleagues and friends and by all who had the pleasure of working with him. His hobbies were gardening and music, of which he had great knowledge and which occupied most of his leisure hours. He is survived by three sons and a daughter.

Ewing joined The Institution as a Student in 1894 and was elected an Associate in 1897, an Associate Member in 1901 and a Member in 1910. He served on the Transvaal Local Committee from 1937 to 1945. W. D. W.

JAMES FREDERICK FIELD

James Frederick Field, B.SC., who died on the 20th October 1958, was born on the 15th October 1903 at Galashiels. He received his early education in Scotland, later attending Heriot-Watt College, Edinburgh, where he obtained the B.Sc. degree. This was followed by practical training and experience with the British Thomson-Houston Co. Ltd. at Rugby and with the General Electric Co. at Schenectady, the Brooklyn Edison Co. in New York, and the Calico Printers' Association in Manchester.

Transferring to Edinburgh after seven years with the Central Electricity Board in London, he was successively deputy, then chief city electrical engineer and manager and B.E.A. divisional controller for South-East Scotland. From his return to C.E.A. headquarters in 1955 till his death, he devoted much of his time to development of the steam cycle which bears his name.

Carnot's brilliant exposition of fundamental principles and less well known cogent remarks on their practical application early caught his imagination. In 1939, his closely reasoned paper on 'Comparison of efficiencies of steam-generating plant' was awarded a Telford Premium by The Institution of Civil Engineers. Later, the phenomenal development of the gas turbine led him to propose a novel low-pressure high-temperature steam cycle. It combined high-average-temperature heat intake in a steam superheater, with power output and heat rejection in a steam turbine and condenser, the regenerative stage being closed by a steam compressor added to the conventional feed heaters. He threw himself with his usual enthusiasm into the struggle to bring it to fruition, but failing health severely curtailed his efforts. The idea associated with his name remains.

In the more conventional sphere he was responsible for the design and construction of Portobello 'B' power generating station, which for four years held the British record for thermal efficiency and also for equally important availability.

A highly strung, fearless, very likable and, at times, exasperating personality, he died, burnt out by his own nervous energy, at the comparatively early age of 55. He is survived by a son and a daughter.

He joined The Institution as an Associate Member in 1936 and was elected a Member in 1943. He served on the Scottish Centre Committee from 1944 to 1947. J. D. P.

CHARLES A. GROVER

Lt.-Col. Charles A. Grover, T.D., who died on the 14th August 1958, was born on the 20th May 1890. He was a man of varied interests and experience. He was educated at various London County Council schools and at Shoreditch Technical Institute, continuing with practical training at W. T. Henley's Telegraph Works Co. Ltd., Woolwich, and part-time study at Woolwich Polytechnic. In 1910 he left the company to serve with the Peninsular and Oriental Steam Navigation Co. and returned to Henley's in 1914 as assistant electrician.

In 1919 he became chief assistant in the research laboratories of the company, transferring, in 1924, to the contract department to take charge of testing in the field, a subject in which he was well versed and on which he was the joint author of a book. He became chief technical assistant in the contract department in 1937, was mobilized in 1939 and released a year or so later. He returned to Henley's and, in 1943, took up work in the advertising department, where he had much to do with the house journal, *Distribution of Electricity*. He retired in 1956.

The Royal Engineers (Territorial Army) claimed a good deal of his time. He served 17 years with them, reaching a position of command in 1938. His recreations included water-colour painting, model-locomotive building, and carpentry, to which should be added his interest in mathematics and problems therein. He was a prominent Freemason and a member of the Batti-Wallahs. His later years were saddened by the death, in 1953, of his son in a flying accident and, two years later, of his wife, two events not unconnected. He is survived by a married daughter.

He joined The Institution as a Graduate in 1915 and was elected an Associate Member in 1916 and a Member in 1938. E. B.

MICHAEL GUEILIKMAN

Michael Gueilikman, who was born on the 18th July 1892 in Dniepropetrovsk, Russia, died on the 22nd September 1958 at Llandudno, where he had moved on retiring after 43 years' service with the Sturtevant Engineering Co.

He received his early education in Russia and then, from 1909 to 1914, studied at the University of Liège, where he was awarded the University's Diploma in Electrical Engineering. He had just completed his studies when the First World War broke out, and he served in the Belgian Army at the siege of Liège. After the capture of that city by the Germans, he fell back with the retreating Belgian Army to Calais, eventually making his way to England.

Joining the Sturtevant Co. in August 1915, after six months with London United Tramways, he spent his whole life with that organization, except for two years' service in the British Army. In his earlier years he had the opportunity of working in several of the firm's various engineering departments, especially those devoted to fans and fan applications. In 1935 he was appointed deputy manager of the electrostatic-precipitation department and in this new post had much to do with the modern development of electrostatic precipitators. In fact, many of the plants of that type operating today in the United Kingdom and abroad owe their success to his hard work and engineering skill. In 1950 he became head of this department and in 1952 was appointed a director of the company. Shortly afterwards he took over control of a group of departments and remained in this position until he retired in June 1958 owing to failing health. He is survived by his widow.

He joined The Institution as an Associate Member in 1935 and was elected a Member in 1947. He was also a Member of The Institution of Mechanical Engineers. H. W. W.

HERBERT HENRY JAGGER

Herbert Henry Jagger, who was born in Bradford, Yorkshire, on the 16th November 1896, died in Cape Town on the 28th October 1958. He was educated at Grange Road Secondary School, Bradford, and served his apprenticeship as a fitter and turner at various Bradford engineering works. He joined the Royal Navy during the First World War, serving as an engine-room artificer. After the war he spent some years with the British India Steam Navigation Co.

In 1921 he was appointed steam engineer at the Valley Road power station, Bradford. Two years later he was appointed to a similar position at the Electricity Supply Commission's Colenso power station, Natal. In 1928 he became superintendent of the Commission's Salt River power station, Cape Town. He held this position until 1933, when, with the inception of the 'pooling' agreement between the Electricity Supply Commission and the Cape Town City Council, he was appointed superintendent of the pooled power stations. He became manager of the Electricity Supply Commission's Cape Western Undertaking in 1946 and held that position until his retirement in 1957.

Harry Jagger was a man of forceful but disciplined character. He attacked every problem with which he was confronted with the energy and tenacity of purpose that characterized his whole life and career. He demanded a high standard of work and loyalty from his staff, who knew that if they measured up to these standards they were assured, in return, of his support and loyalty.

If ever a man merited the appellation 'self-made', it was he. Of the many who will recall his considerable mathematical skill, few will know that that skill was acquired only by dint of intensive private study, much of it during his career at sea. His investigations into the severe main steam-pipe vibrations which had been experienced at the City Council's Table Bay power station were subsequently presented as a thesis to The Institution of Mechanical Engineers.

He was a keen golfer until ill-health forced him to forsake this game for his hobby of a home workshop. That he never lost his skill as a machinist was evidenced by the work he produced from his workshop, an astronomical telescope being a particularly fine example.

He joined The Institution as an Associate Member in 1943 and was elected a Member in 1947.

MARMADUKE ALFRED PIKE

Marmaduke Alfred Pike, whose death occurred in 1958 at Nelson, New Zealand, was born on the 20th June 1890. He was educated at Palmerston North School and received his technical education part-time at Palmerston North and Nelson Technical Schools.

He joined the service of the New Zealand Post Office at Palmerston North in 1907 and later qualified as a junior engineer, being stationed successively at Wellington, Palmerston North, Christchurch, Timaru, Nelson, Masterton and Hamilton. He was appointed district engineer at Dunedin in 1937, transferring to the head office to become superintending engineer in 1939, deputy engineer-in-chief in 1942 and engineer-in-chief in 1944. He retired in 1945.

He played a full part in laying the foundations for the post-war expansion of the telecommunication services in New Zealand. Essentially of the older school of engineers, he was noted for a retiring disposition, a strict application to duty and a quick appreciation of the other man's point of view. During the latter part of his career, he was called upon to shoulder the added responsibilities and worries brought about by war, and he is remembered for the able leadership he displayed in those days.

He is survived by two married daughters.

Pike joined The Institution as an Associate Member in 1928 and was elected a Member in 1942. He served as Local Honorary Secretary of the Council in New Zealand from 1940 to 1945.

E. H. R. G.

BULUSU RAMA SOMAYAJULU

Bulusu Rama Somayajulu was born on the 7th December 1900, in the now new State of Andhra Pradesh, and died in Hyderabad, the capital city, on the 13th May 1958 after a brief illness. He received his technical education at the College of Engineering, Madras, serving an apprenticeship with the Andhra Paper Mills, Rajahmundry, before joining the English Electric Company's branch office at Madras.

In 1927 he joined the subordinate service of the Madras Public Works Department at Mettur Dam. He was successively promoted assistant engineer and divisional engineer and then became superintending engineer of the Papanasam electricity system and the Andhra power system, in the service of the Madras Government. He became general superintendent of operating systems in 1948, which position was later designated chief operation engineer.

He went to Canada in 1951 under the Colombo Plan, visiting the United Kingdom on his way back. On his return to India in 1952, he became chief engineer for electricity of the composite State of Madras and was in this office until the formation of the new Andhra State in 1953. He was then made chief engineer for electricity of the Andhra State and, after its amalgamation with parts of Hyderabad, of the new State of Andhra Pradesh. In this position he had to integrate systems in the old Hyderabad State with hydroelectric systems and even carry on to a great extent supplies of power from small Diesel generating stations. At the time of his death he was in his third extension after superannuation and was primarily responsible for the successful completion of the Machkund hydro-electric project, from which power is being supplied to the Caltex refinery at Visakhapatnam and also to the new inter-State hydro-electric project at Tungabhadra.

Somayajulu's entire interest was in his work, and in this he showed his capacity to organize plans and execute the various projects that demanded his immediate attention. As an engineer he had a great capacity for obtaining loyalty, devotion and co-operation from all who served with him or under him. His only known hobby was an occasional visit to the cinema. One remembers him as a patient, courteous and friendly gentleman who always gave others a hearing. He is survived by his widow and a large family. Two of his sons are making their way as electrical engineers in the Electricity Department of Andhra Pradesh.

He joined The Institution as a Graduate in 1925 and was elected an Associate in 1929, an Associate Member in 1934 and a Member in 1949. He was also a Member of The Institution of Engineers, India. N. C. S. K.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as these separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.

Applications, quoting the serial number of the paper, monograph or reprint, as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually—if they do not take the Part of the Proceedings in which it will be republished—are urged to apply in due course for a reprint, as this is the final and correct version and includes the discussion.

PAPERS

Method for the measurement of very high Q-factors of electromagnetic resonators *Paper* 2847 R: *Part B*

F. H. JAMES

THE author outlines the problem of measuring the Q-factors of resonators for the C.E.R.N. linear accelerator. The Q-factors involved are of the order of 10^5, and the resonant frequencies are in the range 200–300 Mc/s. The methods considered are briefly discussed, and the one which seems most suitable employs sinusoidal amplitude modulation.

The accuracy depends on a low-frequency phase measurement, and, for this reason, accurate knowledge of the power law of the detector is not required. The modulation component undergoes a phase shift owing to the high Q-factor of the resonator. When this attains a magnitude of $\pi/4$ rad, the Q-factor is given by one-half of the ratio of the resonant frequency to the modulation frequency. Two alternative procedures are described. A mathematical treatment of the theory and some experimental results are included in the appendices.

To be read on the 23rd February 1959

Influence of consumers' load/consumption characteristics on metering practice *Paper* 2863 M: *Part A*

L. B. S. GOLDS

THE results are presented of further investigations into the load/consumption characteristics of domestic consumers' installations. These are combined with the results of pilot tests, giving over 400 sets of data; and their relation to the performance, utilization and design of integrating meters is discussed.

A system is proposed for weighting the errors found in 'off-service' sample-meter tests at certain load currents so as to arrive at the total meter-registration error, and a formula is given for the economic service period. Suggestions are made for the setting of a recertification period by reference to the statistical distribution of meter 'weighted' errors, as determined by sample tests at specified load currents. A possible revision of the standard ratings of meters is considered, and proposals are put forward for the better utilization of existing meters to achieve maximum service and recertification periods.

Further tests are recommended on installations of other classes of consumer, and it is suggested that a sufficient number of load-analysing meters be permanently installed in representative consumers' premises of the various classes.

To be read on the 3rd March 1959

Reliability and life of impregnated-paper capacitors *Paper* 2866: *Part B*

J. P. PITTS, B.SC.(ENG.)

REFERENCE is made to present trends in the encasing and hermetic sealing of paper capacitors. After a statement of the primary causes of breakdown, the problems of impregnated-paper-dielectric failure under d.c. and a.c. stress are examined in the light of knowledge of various breakdown mechanisms gained principally during the last decade.

Possible ways of prolonging capacitor life under d.c. stress are considered, and measures to eliminate early failures under both d.c. and a.c. stress are discussed. Achievement of very great reliability is thought to be less difficult with a.c. than with d.c. stress.

To be read on the 5th March 1959

High-quality microphones *Paper* 2798 R: *Part B*

M. L. GAYFORD, B.SC.(ENG.)

A REVIEW of present-day practice in the design and operation of high-grade microphones used for broadcasting, sound reinforcement, sound recording, acoustical measurement, etc.

General requirements, basic operating principles and design details are given for typical microphones of various types. They are classified acoustically into omnidirectional and directional categories for the purpose of discussion and analysis.

To be read on the 23rd March 1959

MONOGRAPHS

Square-loop ferrite core as a circuit-element *Monograph* 327 M

C. H. LINDSEY, M.A., PH.D.

A QUANTITATIVE theory is presented to explain the shape of the output waveforms when square-loop ferrite cores are switched. This is based on the qualitative theory of Menyuk and Goodenough. Various useful equations arising from the theory are deduced, and it is shown that the agreement with experiment is reasonable. The theory indicates which parameters of the material need to be known to predict its behaviour.

Stability criteria for linear systems *Monograph* 328 M

O. P. D. CUTTERIDGE, M.SC.(ENG.), PH.D.

IT is shown that the various stability criteria for linear systems can be conveniently obtained and interrelated by means of continued fractions. A new canonical form for a Hurwitz polynomial as a product of continued fractions is given, together with an alternative set of determinantal criteria with determinants of about half the order of the Hurwitz determinants.

Effect of irradiation on breakdown voltage of sphere-gaps in air under direct and alternating voltages *Monograph* 329 M

E. KUFFEL, M.SC.

BREAKDOWN voltages were measured with and without the irradiation from 0·5 mg of radium. Spheres of diameters 2–25 cm were used, and some experiments were made with parallel-plate electrodes. The irradiation lowered the breakdown voltage by as much as 4% in some circumstances. A maximum effect was obtained with a particular gap length, and this length depended on the size of the sphere electrodes.

SOME RECENT BOOKS

S. H. CALDWELL
SWITCHING CIRCUITS AND LOGICAL DESIGN

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1958. 686 PP. £5 12S.

ELECTRICAL engineering is notorious for its development of powerful mathematical methods which have nothing specifically to do with electricity. This is not surprising, for the science of logically prescribed actions, to which such concepts belong, has as yet no home of its own and remains naturally attached to the field where its usefulness was first recognized.

The present volume offers a most readable course in that branch of the new science which is concerned with two-valued (all-or-none) control of action. The central feature is the representation of switching circuits by transfer functions in Boolean algebra (wherein variables have only the values 1 or 0). The dramatic simplification of complex networks which this facilitates is well illustrated, and various graphical ways of representing such functions (and their correlates in symbolic logic) are discussed and evaluated. Problems for the reader are a valuable aid to study throughout the book.

A work of 686 pages could be summarized here only by reprinting the index. Not the least of its merits is its collation of hitherto scattered material on topics as diverse as solid-state switches and error-correcting codes; but the emphasis is always on the switching problems set or solved in each case. A minor regret is that the author has retained the symbolism in which switches look like capacitors, in preference to the unambiguous British Standard convention.

One felt less happy than elsewhere with the introductory discussion of the relation of 'two-valued' systems to servo systems. Since many servos can pass smoothly from a continuous to a two-valued mode of operation according to the gain of their amplifier, it seems odd to maintain (p. 3) that 'the objectives of the two systems are quite different' and that 'they can only be contrasted' rather than 'truly compared'. But this is a small point.

The work as a whole is impressively clear and concise; and although at present the average engineer's switching problems might have to be more than usually complex to justify the learning of such sophisticated techniques, the need for them is likely only to increase. The new way of thinking which it offers has in any case sufficient interest in itself to make the book rewarding reading.

H. INGHAM and L. TAYLOR HARRINGTON
INTERFIRM COMPARISON FOR MANAGEMENT—VOL. 3

BRITISH INSTITUTE OF MANAGEMENT. 1958. 70 PP. 17S. 6D.

'. . . it is dangerous to rely exclusively on comparisons over time between one's own figures; though they may appear to indicate satisfactory progress, they have to be compared with ratios of other firms before the competitive position of the business can be adequately judged.'

This quotation summarizes the simple gospel which the authors preach in this attractively presented publication. They describe lucidly a tool of management, the practical value of which does not seem, from the appended summary of surveys already undertaken—the majority in the United States—to be sufficiently exploited in this country. They answer some of the doubts which might arise in the manager's mind concerning the 'confidentiality', comparability, and cost of such surveys. Their final paragraph 'Getting started', which represents a gentle push down the road they have pointed out, shows that they have made a successful attempt to appreciate the attitude and needs of the practising manager.

The booklet may usefully find its way into the reading list of management-training courses, particularly those conducted at a more senior level where this tool becomes a matter for practical consideration.

Y. H. KU
ANALYSIS AND CONTROL OF NONLINEAR SYSTEMS

NEW YORK: RONALD PRESS. 1958. 360 PP. £3 17S.

THE substance of this book is mainly an exposition of Ku's extension to higher-order non-linear systems of the phase-space method of studying the behaviour of second-order non-linear systems. As such, it will be valuable to those who wish to study non-linear vibrations and oscillations and the transient response of non-linear physical systems of the third and higher orders.

Ku has developed constructions for the various trajectories in the phase plane which, given the non-linear differential equations governing the system, enable one to deduce the conditions for stability and also the transient response in suitable conditions, no matter what the order of the system. He applies this method to certain familiar problems such as van der Pol's equation and the synchronous motor. He goes on to apply it to coupled electric circuits with non-linear components, which are of great interest—work which is original and not published elsewhere.

Much space is taken up by well known problems in linear and non-linear vibrations, treated in standard ways. No doubt these have been included for the sake of completeness, but in general they are not presented nearly as well as in R. R. Stoker's 'Non-linear vibrations' and could have been omitted.

There is little mention of the control of non-linear systems until the last two chapters, which are no more than a brief introduction to this big field. The transient behaviour of systems containing well known non-linearities, such as contactors, saturation and backlash, is investigated using phase-plane and describing-function methods; and there is some discussion in the last chapter of the effect of non-linearities in different parts of the loop and of possible methods of improving transient response by the use of non-linear networks.

All this is very elementary and better set out in books previously published, and no mention is made of non-linear systems with random inputs. The control engineer will find little in this book to assist him directly in the design of non-linear control systems. However, if he uses it to become *au fait* with the author's ways of construction in the phase plane and applies them to his non-linear problems, he should get a much clearer picture of how his non-linear systems will

behave and may well be in a better position to improve such systems by the use of proper compensating networks.

Where Ku is describing his own work his style is lucid and, taking into account the difficulty of the subject, easily understandable; but in other sections there is evidence that the material has been taken from other works without due regard to the context. This, combined with contraction into a small space, makes some of these sections extremely difficult to follow. In addition, there are a number of rather irritating misprints.

There is an excellent bibliography of books and papers on non-linear systems, which is of considerable value. In this, Liapounov is mentioned, but it is a surprising omission that he is not mentioned on p. 9 among the other earlier workers in this field. Throughout the book there is no mention of Russian work, which is unfortunate, since Russians have made some of the most important contributions in the field of non-linear control systems.

It is a pity the author chose such a high-sounding title for the book; he should have used the sub-title ('Nonlinear vibrations and oscillations in physical systems') or, better still, restricted the content to his work on phase-space methods of investigating non-linear systems, which is a most valuable contribution to the subject and worthy of a volume on its own.

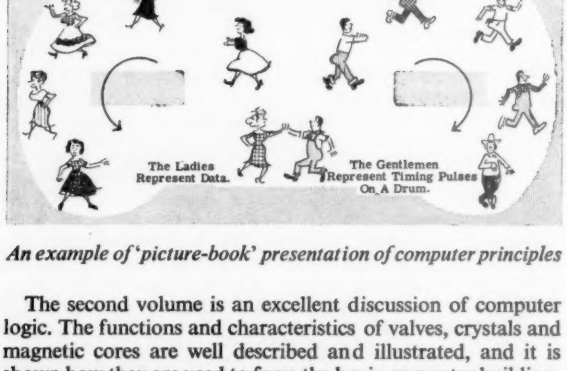
J. S. MURPHY

BASICS OF DIGITAL COMPUTERS

NEW YORK: RIDER. 1958. 3 VOLS., EACH OF 130 PP. £3 4S. FOR THE SET

HERE is a noble attempt to present the fundamental principles of digital computers in a form which is straightforward and interesting to both designer and user.

The first of the three short volumes reviews the development of computers, explains decimal and binary arithmetic, and introduces the reader to computer language. The mode of operation of a computer and the function of single and multi-address coding systems are described. A brief account is given of the basic principles of programming.


STANDARD TIMING IS LIKE A BARN DANCE
WHERE EVERYONE FINISHES THE DANCE WITH HIS ORIGINAL PARTNER
The Ladies Represent Data.
The Gentlemen Represent Timing Pulses On A Drum.

An example of 'picture-book' presentation of computer principles

The second volume is an excellent discussion of computer logic. The functions and characteristics of valves, crystals and magnetic cores are well described and illustrated, and it is shown how they are used to form the basic computer building-blocks. Flip-flops, counters, gates and clamps are explained and their performance and shortcomings considered. The author shows how the blocks are assembled to perform the basic functions of arithmetic.

The last volume compares and illustrates the various types of memory: delay lines, cathode-ray tubes, magnetic drums and ferrite cores. The author surveys the problem of timing the sequences of computer operation and the function of the control circuits and presents an account of input-output units: paper tape, cards, magnetic tape and high-speed printers.

The volumes form part of a series making a new departure in technical literature. The publishers evidently believe that, as computers come into common use, it is not just the top people who must be kept up with the times and that the strip cartoon may play a useful part. The topics are copiously illustrated and lucidly explained, and the digital computer appears stripped of the jargon and symbolism which have tended to shroud it with an air of mystery. The pictures serve the dual purpose of illustrating the technical points and providing some amusing comparisons.

Gone is any flavour like that of propositions in Euclid; the diagrams are good, but some of the pictures are a little remote and distracting.

J. O. PERRINE

PHYSICS AND MATHEMATICS IN ELECTRICAL COMMUNICATION

NEW YORK: RIDER. 1958. 261 PP. £2 10S.

THE author, in his preface, refers to two other books: 'Calculus made easy' by S. P. Thompson and 'Exponentials made easy' by G. de Bray, which he acknowledges to have been models of inspiration to him in writing the present volume. There can be no doubt that he has, in many respects, maintained the high standard set by his predecessors in the effort to present simple and convincing arguments coupled with physical explanations of the problems discussed.

It is indeed surprising how even those already knowledgeable in the subject can, by following the reasoning given, sometimes get a fresh insight into its finer points and particularly a better understanding of the physical basis of the steps taken. Some readers may feel that on occasion the author tends to overemphasize ideas, giving the impression of labouring the discussion. But whatever the reaction to a study of this book, there can be no doubt about its essential merits and its value to those working in the field of the rather elementary mathematics concerned.

The title of the book is unquestionably misleading, because the material included goes little beyond the mathematics of circular functions and simple harmonic motion, the hyperbola and hyperbolic functions, exponentials, and Maclaurin's and Demoivre's theorems, each section being illustrated by applications to the transient and steady-state behaviour of electrical circuits. In fact, a substantial part of the material can be found in any standard textbook on line propagation and circuit theory; but, of course, the novelty of the present volume lies in the presentation of that material.

It would be too much to expect no mistakes in a book of this kind, but there is little of which one can seriously complain. Apart from a few typographical errors, there is, however, a statement on p. 236 to the effect that four different code 'operators' mean the same. Only two of these are actually the same, and the similarity between the four is otherwise restricted to symbolizing counterclockwise rotation of a vector. This is clearly an isolated slip, and on the whole the book is well produced, with excellent illustrations. Both author and publisher are to be congratulated on a very useful work.

G. R. PARTRIDGE

PRINCIPLES OF ELECTRONIC INSTRUMENTS

PRENTICE-HALL. 1958. 393 PP. £3 14S.

THE theory and design of a wide variety of electronic instruments are dealt with in a comprehensive manner in this book. It is primarily intended to assist research workers and practising engineers in their instrumentation problems, and sufficient practical information is given to enable actual design to be carried out. Full theoretical treatments are given where necessary, based on the assumption that the reader is conversant with mesh and nodal analysis and the Laplace transform.

The volume has been compiled from a series of lectures on instrument design to postgraduate students. It would seem that this is an excellent method of preparation, because the presentation throughout is perfectly clear, and the text is delightfully easy to read.

It opens with a general discussion of the advantages of electronic instruments. This is followed by a chapter on the significance of voltage measurement, in which the errors occurring in such measurement are fully discussed, largely on a statistical basis. The five following chapters deal with almost every known type of valve voltmeter, including electrometer devices. A concise treatment of feedback theory, including stability criteria, is included here to assist the theoretical analysis. A useful feature of this part of the work is the inclusion of descriptions and analyses of several well known commercial valve voltmeters.

Subsequent chapters deal with electronic wattmeters, frequency-measuring instruments, phase meters, instruments for component testing, and digital display systems. The remaining seven chapters are concerned with instruments for measuring non-electrical quantities, including mechanical displacement, velocity, flow, time, sound, light, pressure, temperature, and radioactivity.

The author has compressed a remarkable amount of useful information into a moderately sized book and has provided adequate references throughout. It is a really valuable addition to the literature.

A. ROBERTS

UNDERGROUND LIGHTING IN MINES, SHAFTS AND TUNNELS

LONDON: TECHNICAL PRESS. 1958. 292 PP. £3 3S.

THIS is the most comprehensive review of mine lighting yet attempted. It is divided into three sections, the first, of over 100 pages, being devoted to the fundamentals of lighting, the second to mine and tunnel lighting problems, and the third to lamps and lighting equipment.

In the first section, the author has made full use of the opportunity to employ the latest agreed terminology and definitions, and the care taken over this undoubtedly enhances the value of the work. Photometry, illumination calculations, the eye and vision, and the design of the visual field are dealt with in no summary fashion but with a completeness which will be particularly welcomed by the serious lighting student.

The second section deals very comprehensively with mine-lighting problems, and the student or engineer who has thoroughly grasped the fundamentals given in the first section will appreciate the way in which the author links theory and practice, particularly in the use made of isocandle diagrams and of luminance concepts. (Surface lighting, incidentally, is by no means neglected, despite the title of the book.) The chapter on tunnel and subway lighting includes much recent material which will interest engineers in a wider field.

The concluding section, on lamps, lighting equipment, installation and maintenance, is a useful and up-to-date review from which nothing of importance seems to have been omitted.

The book is copiously illustrated, is well produced and indexed, and has a generous type size. The bibliography and references accompanying each chapter will further commend it to serious students.

With this book the author makes a significant contribution, both to mining and lighting engineering.

A. A. SHEPHERD

AN INTRODUCTION TO THE THEORY AND PRACTICE OF SEMICONDUCTORS

CONSTABLE. 1958. 206 PP. 18S. 6D.

THIS is a relatively small volume, containing less than 70000 words and 100 diagrams. The bibliography comprises 134 references. The quality of the paper is high, the diagrams are well produced, and one finds no typographical errors.

In spite of the generality of the title, the book is devoted almost exclusively to germanium and silicon. A short, final chapter describes the properties of a number of group III/group V compounds. Many books on the physics and technology of semiconductors and transistors have been published in recent years. In the present work, a larger fraction than normal is devoted to device technology. It is clear that the author is more familiar with this aspect of semiconductor activity, and the sections devoted to device fabrication are the best in the book. Unfortunately, device technology tends to change rather rapidly, which may shorten the useful life of the book. For example, on p. 90 it is stated that, to apply the floating-zone technique to silicon, 'the diameter of the rod should not exceed 1 cm'. Single-crystal silicon rods of 1 in. diameter, obtained by the floating-zone method, are currently available commercially. It may be remarked that there are no references to publications after 1956.

On the theoretical side, the book is a survey of results rather than an introduction. Theoretical formulae are quoted without any indication of their range of validity or the assumptions on which they are based. For example, carrier mobility is stated to be proportional to temperature to the power $-3/2$. This is, indeed, the result of a simple theory based on acoustic mode-scattering, but, as the author is no doubt aware, it does not agree with the experimental behaviour of any of the semiconductors mentioned in the book. This point is of only academic interest to the engineer, but it may confuse the serious student of semiconductor physics. Perhaps more important is the fact that part of the explanation of the Shockley drift-mobility experiment is incorrect, though the reader will perhaps discover this for himself by study of the reference given. Incidentally, the reader is assumed to understand minority-carrier injection during the description of the drift experiment on p. 31; the phenomenon is explained on p. 106 et seq.

The book can be recommended to the user of semiconductors who is interested in the fabrication of the devices and the reasons for their advantages and limitations. It cannot be recommended as a textbook of semiconductor physics.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card.

February 1959

M **16–17** *Monday–Tuesday* Specialist discussion meetings on 'New digital-computer techniques' (all wishing to attend must register; form available on application)

R **18** *Wednesday* C. N. SMYTH, M.A., B.SC.(ENG.), M.B., B.CH., *and* J. SAYERS. Lecture on 'Ultra-sound image converter'†

RM **20** *Friday* V. J. TERRY, B.SC.(ENG.), *and* E. P. G. WRIGHT. Lecture on 'Measurement of errors in data transmission for the design of detecting and correcting equipment'

R **23** *Monday* D. T. GJESSING, B.SC., 'Simple investigation of cross-modulation distortion arising from pulling effect in a frequency-modulated klystron' (Paper 2789 R) *synopsis:* January 1959

G. W. BUCKLEY, M.A., *and* J. GUNSON, B.A. 'Theory and behaviour of helix structures for high-power pulsed travelling-wave tube' (Paper 2788 R) *synopsis:* January 1959

H. J. CURNOW, B.SC., *and* L. E. S. MATHIAS, M.SC. 'Multi-cavity klystron with double-tuned output circuit' (Paper 2825 R) *synopsis:* January 1959

F. H. JAMES 'Method for the measurement of very high Q-factors of electromagnetic resonators' (Paper 2847 R) *synopsis:* see p. 110

S **25** *Wednesday* F. S. FAY, M.A., J. A. THOMAS, B.SC., D. LEGG, B.SC., *and* J. S. MORTON, B.SC. 'Development of high-voltage air-break circuit-breakers with insulated-steel-plate arc chutes' (Paper 2746 S) *synopsis:* December 1958

26 *Thursday* Annual Dinner (at Grosvenor House, Park Lane, London W.1, at 7 for 7.30 p.m.)

March 1959

M **3** *Tuesday* L. B. S. GOLDS 'Influence of consumers' load/consumption characteristics on metering practice' (Paper 2863 M) *synopsis:* see p. 110

O **5** *Thursday* J. P. PITTS, B.SC.(ENG.) 'Reliability and life of impregnated-paper capacitors' (Paper 2866) *synopsis:* see p. 110

MED **6** *Friday* The particulars of this meeting are to be announced* (at 6 p.m., tea at 5.30 p.m.)

9 *Monday* T. M. H. STUBBS will open a discussion on 'Need British Standards be modified to obtain trade abroad?'*

E **10** *Tuesday* A. C. SIM, B.SC., will open a discussion on 'The Laplace transform—a tool for the electrical engineer'* (at 6 p.m., tea at 5.30 p.m.)

S **11** *Wednesday* Section Dinner-Dance (at the Connaught Rooms, Great Queen Street, London W.C.2, at 7 for 7.30 p.m.)

U **12** *Thursday* A. P. FOSTER, B.SC. 'Coal-mining and electricity'‡

P. D. HOUSE, B.SC.(ENG.) 'Electric drives in the paper industry'‡

M. J. L. WILLISON 'Standardization and simplification of switchgear'‡

(joint meeting with the London Graduate and Student Section)

M **17** *Tuesday* G. PHILLIPS. Informal lecture on 'Electrical uses of atomic spin'†

R **18** *Wednesday* C. W. OATLEY, O.B.E., M.A., M.SC. Lecture on 'New amplifying techniques'†

* No advance information will be available, and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

March 1959 (continued)

R **19–20** *Thursday–Friday* Convention on Stereophonic sound recording, reproduction and broadcasting (all wishing to attend are required to register; full details and registration form obtainable from the Secretary)

20 *Friday* SIR ARNOLD PLANT, B.SC., B.COM. Fifth Graham Clark Lecture. 'Engineering in an expanding economy'‡ (joint meeting with The Institutions of Civil and of Mechanical Engineers, at The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1, at 6 p.m., tea at 5.30 p.m.)

R **23** *Monday* M. L. GAYFORD, B.SC.(ENG.) 'High-quality microphones' (Paper 2798 R) *synopsis:* see p. 110. (in the Lecture Theatre)

F. A. BENSON, D.ENG., PH.D., *and* P. M. CHALMERS, B.ENG. 'Effects of argon content on the characteristics of neon–argon glow-discharge reference tubes' (Monograph 321 R) *synopsis:* December 1958. (in the Tea Room)

S **25** *Wednesday* G. B. HARPER 'The selection of insulation levels and tests for high-voltage transformers' (Paper 2804 S) *synopsis:* January 1959

‡ No advance information will be available

British Nuclear Energy Conference

DETAILS of five forthcoming meetings of the British Nuclear Energy Conference are given below. Tickets of admission are not required. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the *Journal of the B.N.E.C.* regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1959

FEBRUARY 27 *Friday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

Informal discussion on CHOICE OF GAS TEMPERATURES AND STEAM-PRESSURE CONDITIONS IN NUCLEAR POWER STATIONS

MARCH 3 *Tuesday* (5.30 p.m.)

Sponsoring body: The Joint Panel on Nuclear Marine Propulsion

Place of meeting: The Institute of Marine Engineers, 76 Mark Lane, London E.C.3

METALLURGICAL PROBLEMS RELATED TO NUCLEAR PROPULSION OF SHIPS
H. M. Finniston

MARCH 13 *Friday*

Place of meeting: Central Hall, Westminster, London

LECTURE SYMPOSIUM 'GENEVA, 1958'

The British Nuclear Energy Conference are holding a one-day lecture symposium to help scientists and engineers to assimilate the material produced at the 2nd United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, 1958. The Geneva papers will be classified into seven groups, and leading experts will attempt to highlight the most important aspects of the new information. The lectures will be printed in full in the April 1959 number of the *Journal of the B.N.E.C.* Further particulars may be obtained from the Secretary, B.N.E.C., 1–7 Great George Street, London S.W.1

APRIL 10 *Friday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

James Clayton Lecture on CANADIAN ATOMIC-ENERGY DEVELOPMENT IN REVIEW AND PROSPECT W. B. Lewis

APRIL 15 *Wednesday* (10 a.m.)

Sponsoring society: The Institute of Metals

Place of meeting: Church House, Westminster, London S.W.1

METALLURGICAL DEVELOPMENTS OUTLINED AT THE GENEVA CONFERENCE ON PEACEFUL USES OF ATOMIC ENERGY H. M. Finniston

*Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

ANGELO, E. J. 621.38

Electronic circuits. A unified treatment of vacuum tubes and transistors

London, McGraw-Hill, 1958. pp. xiii, 450. 24 × 16cm. £3 10s.

The author discusses vacuum tubes and transistors as rectifiers and amplifiers, and their use in pulse and other circuits, and considers such circuits as active networks. To be reviewed.

ASELTINE, J. A. 517

Transform method in linear system analysis

London, McGraw-Hill, 1958. pp. xvi, 300. 24 × 16cm. £3 6s.

Deals with the application of integral transforms to the analysis of physical systems which can be described by linear differential equations. The mathematical treatment is not made more rigorous than is necessary. It will be reviewed in a future issue.

BAATZ, H. 621.316.93

Überspannungen in Energieversorgungsnetzen (Voltage surges in power-supply networks)

Berlin, Springer, 1956. pp. viii, 295. 24 × 16cm. £2 18s. 11d.

Covers the effects of lightning on overhead lines, the surges produced, and protective equipment for lines and networks. Protective measures against internal surges on a system are also considered.

BARNES, D. E., and TAYLOR, D. 539.16

Radiation hazards and protection

London, Newnes, 1958. pp. x, 178. 22 × 14cm. 30s.

This book explains the nature of the hazards, the levels of radiation which are accepted as safe, the protective methods for obtaining such safe levels, and methods of measurement and monitoring. A review of the work will appear in a future issue.

BELL, S. W., and MATLEY, H. 517

Mathematics for Higher National Certificate—Vol. 2 (electrical)

Cambridge, Cambridge University, 1958. pp. x, 486. 22 × 14cm. 35s.

Intended to cover the work done in the final year of the Higher National Certificate in Electrical Engineering. Exercises to be worked are given at the end of each chapter; the answers are supplied at the end of the book. A review of this book appeared in the December 1958 Journal, p. 677.

BENDAT, J. S. 621.391

Principles and applications of random noise theory*

London, Chapman and Hall, 1958. pp. xv, 431. 23 × 15cm. £4 8s.

Explains the principles of random-noise analysis and optimum filtering techniques in understandable engineering language, emphasizing physical meanings and mathematical restrictions. The book shows how to formulate and derive solutions to difficult problems. A review will appear in a future issue.

BRIGGS, G. A. 621.395.623.7

Loudspeakers. 5th edition*

Bradford, Wharfedale Wireless Works, 1958. pp. 336. 22 × 14cm. 19s. 6d.

Originally a slender work of 90 pages, this popular book has been rewritten and increased to nearly four times the size of the earlier editions. The author's style is unchanged, and the coverage is still limited to the design and performance of loudspeakers.

CLARKE, A. C. 93 : 621.39

Voice across the sea. The story of deep-sea cablelaying 1858–1958* London, Frederick Muller, 1958. pp. ix, 220. 20·5 × 13·5cm. 18s.

This is a fascinating adventure story which anyone can read and understand. The main theme is the spanning of the Atlantic, first by telegraph cable—described in considerable detail—then by radiotelegraphy and radiotelephony, and finally by telephone cable. The story includes a glimpse of Heaviside's life. A review of this book will appear in a future issue.

CLASON, W. E. 413 = 00

Elsevier's dictionary of nuclear science and technology in six languages: English/American, French, Spanish, Italian, Dutch and German

London, Elsevier, 1958. pp. 914. 23 × 16cm. £7

This is the fourth volume of the series. It contains over 4000 terms defined in English, in which the differences between English and American usage are indicated.

COCKRELL, W. D. *(Editor-in-Chief)* 621.38 (03)

Industrial electronics handbook

London, McGraw-Hill, 1958. pp. ix, 1408. 23 × 16cm. £8 14s. 6d.

A comprehensive handbook covering the components of, and power supplies for, electronic equipment, together with details of control circuits, measuring and recording instruments and computers.

COTGROVE, S. F. 37

Technical education and social change

London, Allen and Unwin, 1958. pp. vi, 220. 22 × 14cm. 25s.

This book considers the social forces which have shaped the growth of technical education in England. It examines the social factors which influence the decision of students to attend courses at the technical colleges and the appropriateness of part-time study to modern needs.

FEINSTEIN, A. 621.391

Foundations of information theory*

London, McGraw-Hill, 1958. pp. x, 137. 24 × 16cm. £2 10s. 6d.

A concise but rigorous exposition of the fundamentals of the mathematical theory of information. No prior knowledge of information theory is necessary, only a familiarity with the elementary concepts of probability theory. A review appeared in the December 1958 Journal, p. 679.

HENNEY, K., and WALSH, C. 621.38

Electronic components handbook—Vol. 2*

London, McGraw-Hill, 1958. pp. 357. 29 × 22cm. £4 17s.

Gives factual information on the following components for the American Services: rectifiers, transistors and batteries for power sources, fuses, circuit-breakers, measuring instruments, printed circuits, solders, fluxes, choppers, fans, motor drives, filters, r.f. transmission lines, and waveguides. To be reviewed.

HUMPHREY, W. S., JUN. 621.316.3

Switching circuits with computer applications*

London, McGraw-Hill, 1958. pp. viii, 264. 24 × 16cm. £3 6s.

A treatment of Boolean algebra with applications to the design of some relay networks. This book will be reviewed in a future issue.

KEMP, P. 621.31

Alternating current electrical engineering. 9th edition

London, Macmillan, 1958. pp. vi, 732. 23 × 15cm. £2

Suitable for students preparing for National Certificate and similar examinations, this well known book deals with principles rather than particular types of machinery and apparatus.

KING, G. J. 621.397.62

Television servicing handbook

London, Odhams, 1958. pp. 280. 23 × 15cm. 30s.

A practical work which lays stress on ways of quickly diagnosing faults.

KOCH, J. (*Editor*), DAWTON, R. H. V. M., and SMITH, M. L. 539.15

Electromagnetic isotope separators and applications of electromagnetically enriched isotopes

Amsterdam, North-Holland, 1958. pp. viii, 314. 23 × 16cm. £2 13s.

The first two parts of this book are technical descriptions of isotope separators and applications of enriched isotopes; the laboratory instruments and the large-scale production units are considered separately. A general account is given of certain fundamental physical problems which are of importance in separator design and have a bearing on future technological development.

KRUGMAN, L. 621.314.7

Fundamentals of transistors. 2nd edition

New York, Rider, 1958. pp. 168. 21·5 × 14cm. $3.50

Deals with the theory, construction and operation of the various types of transistor and their use as amplifiers and oscillators and at high frequencies. Bibliographical references and problems are given at the end of each chapter.

LOVERING, W. F. 621.396

Radio communication*

London, Longmans, Green, 1958. pp. xi, 536. 22 × 14cm. £3

A book on the fundamentals of radiocommunication theory for Higher National Certificate and degree courses. Some knowledge of a.c. theory and the differential calculus is assumed, and M.K.S. units are used. Questions and answers from past examination papers are included. To be reviewed in a future issue.

MILLMAN, J. 621.385

Vacuum-tube and semiconductor electronics*

London, McGraw-Hill, 1958. pp. viii, 644. 24 × 16cm. £3 17s. 6d.

Intended as an introduction to the subject for degree students, it deals with the physical behaviour, as well as the circuit characteristics, of semiconductor devices and vacuum and gas-filled tubes. It will be reviewed in a future issue.

NECHLEBA, M. 621.224

Hydraulic turbines. Their design and equipment*

London, Constable, 1957. pp. 636. 21 × 15cm. £2 5s.

A treatise on the design of the Francis, Kaplan and Pelton types of hydraulic turbine, their control and accessories.

POWELL, L. S. 537

Physics. Vol. 2—Electricity and magnetism

London, Pitman, 1958. pp. xv, 543. 19 × 13cm. 30s.

Intended for students taking classes, this book covers the three-year course in electricity for the Ordinary National Certificate in Applied Physics. Rationalized M.K.S. units are used, and exercises without answers are provided.

RAGAZZINI, J. R., and FRANKLIN, G. F. 621–52

Sampled-data control systems*

London, McGraw-Hill, 1958. pp. vii, 331. 24 × 16cm. £3 14s.

A theoretical treatment applied to the design of sampled-data control systems where stability, response and output ripple are important. It discusses z-transformation, data-reconstruction theory, applications of transform methods to numerical processes, and the theory of sampled random functions. To be reviewed in a future issue.

SAY, M. G. 621.313.3

The performance and design of alternating current machines. Transformers, three-phase induction motors and synchronous machines. **3rd edition***

London, Pitman, 1958. pp. xxi, 664. 22 × 15cm. 37s. 6d.

The text of this well known work has been completely revised and converted throughout to M.K.S. units. Although concerned more with performance than design, it now emphasizes the essential unity of all electromagnetic machines, and there is an introduction to the general circuit theory. It will be reviewed in a future issue.

SHEPHERD, J., MORTON, A. H., and SPENCE, L. F.

Basic electrical engineering* 621.31

London, Pitman, 1958. pp. viii, 310. 22 × 14cm. 27s. 6d.

Intended for students preparing for the Ordinary National Certificate in Electrical Engineering, it follows the main line of the new London University Part I syllabus in electrical engineering. The rationalized M.K.S. system is used throughout, and there is no reference to the C.G.S. system.

ŠIMÁNĚ, Č. 621.384.6

Accelerators of ions and electrons. Principles and basic calculations of linear and circular accelerators*

London, Constable, 1958. pp. 191. 21 × 15cm. 16s.

Discusses electrostatic linear accelerators, including the Van de Graaff high-voltage generator; h.f. linear accelerators; induction accelerators—particularly the betatron—and h.f. accelerators, including the synchrotron, the proton-synchrotron, the cyclotron and the synchrocyclotron, and the electron cyclotron.

SPENKE, E. (translated with additions by D. A. Jenny, H. Kroemer, E. G. Ramberg and A. H. Sommer) 621.315.59

Electronic semiconductors*

London, McGraw-Hill, 1958. pp. xxvi, 402. 24 × 16cm. £4 5s. 6d.

This is a translation from the German with additional material and a series of problems. It is a rigorous introduction to semiconductor physics and the fundamentals of semiconductor devices and was reviewed in the September 1958 Journal, p. 514.

STARR, A. T. 621.39

Telecommunications. 2nd edition

London, Pitman, 1958. pp. ix, 470. 22 × 14cm. 37s. 6d.

Intended to cover the telecommunication syllabus in the London University degree course. Since transient phenomena occur in many problems, the book includes Fourier analysis and operational calculus. There is a short account of microwave technique and waveguide theory.

SUSSKIND, A. K. (*Editor*) 518.5

Notes on analog–digital conversion techniques*

London, Chapman and Hall, 1957. pp. x, 410. 23·5 × 15cm. £4

Suitable for readers with little previous knowledge of the subject, this book is based on lectures given by the staff of the Massachusetts Institute of Technology and deals with the problems created when digital equipment is linked with physical systems. These problems

include the conversion of electrical signals or mechanical displacements into a digital code, and the approximation of a varying signal. The book was reviewed in the December 1958 Journal, p. 682.

TAYLOR, E. O. 621.313.36

The performance and design of a.c. commutator motors including the single-phase induction motor*

London, Pitman, 1958. pp. xviii, 350. 22 × 14cm. £2 5s.

Deals first with matters common to all commutator motors, then with the auxiliary machines for the induction motor, 3-phase commutator motors, and single-phase motors, including the induction type. A number of relevant problems are given with answers. The book is a companion volume to 'The performance and design of d.c. machines' by A. E. Clayton and 'The performance and design of a.c. machines' by M. G. Say. It was reviewed in the September 1958 Journal, p. 515.

TAYLOR, E. O. (*Editor*) 621.039

Nuclear reactors for power generation*

London, Newnes, 1958. pp. vii, 144. 22 × 14cm. 21s.

Based on a series of advanced lectures. Various authors deal with nuclear physics, types of reactor, materials, the physical basis of reactor design, safety and instrumentation, application and economics. A review will appear in a future issue.

WILKES, M. V., WHEELER, D. J., and GILL, S. 518.5

The preparation of programs for an electronic digital computer. 2nd edition

Reading, Mass., Addison-Wesley, 1957. pp. xiv, 238. 24 × 16cm. £3

The first edition was based on experience with the electronic delay-storage automatic calculator (Edsac). This edition is based on a wider experience of stored-programme-type machines.

WILTSHIRE, W. J. (*Editor*) 621.386

A further handbook of industrial radiology*

London, Arnold, 1957. pp. viii, 334. 22 × 15cm. £2 10s.

The authors of the various chapters in this book are members of the non-destructive-testing group of the Institute of Physics. This volume describes techniques developed since the two earlier handbooks were published.

'WIRELESS WORLD' 621.385

Radio valve data. 6th edition

London, Iliffe, 1958. pp. 136. 28 × 21cm. 5s.

Characteristics of 3000 valves, transistors, rectifiers, cathode-ray tubes, voltage stabilizers and thyratrons are given.

OTHER PUBLICATIONS

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, ASSOCIATION FOR COMPUTING MACHINERY AND INSTITUTE OF RADIO ENGINEERS

Proceedings of the Eastern Joint Computer Conference. Papers and discussions presented at the Joint Computer Conference, New York, December 10–12, 1956

New York, A.I.E.E., 1957. pp. 150. 29 × 21cm. 24s.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, ELECTRONIC INDUSTRIES ASSOCIATION, THE INSTITUTE OF RADIO ENGINEERS, WEST COAST ELECTRONIC MANUFACTURERS ASSOCIATION

Proceedings of the 1958 Electronic Components Conference, Los Angeles, California, April 22, 23, 24th, 1958

New York, Engineering Publishers, 1958. pp. 222. 23 × 16cm. £2 8s.

BRITISH BROADCASTING CORPORATION

A u.h.f. television link for outside broadcasts by K. C. Quinton

London, BBC, 1958. Engineering Division Monograph No. 19. pp. 20. 28 × 22cm. 5s.

The B.B.C.'s Mark II mobile studio and control room for the sound broadcasting service by L. E. H. O'Niell

London, B.B.C., 1958. Engineering Division Monograph No. 20. pp. 23. 28 × 22cm. 5s.

BRITISH THOMSON-HOUSTON CO. LTD.

Protective transformers: fundamental principles of operation by J. G. Wellings

Rugby, British Thomson-Houston Co. Ltd., 1958. pp. 48. 21 × 14cm. n.p.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH: BUILDING RESEARCH STATION

The thermal insulation of buildings. Design data and how to use them*

London, H.M.S.O., 1955. pp. vii, 139. 25 × 16cm. 12s. 6d.

ELECTRONICS RESEARCH DIRECTORATE, AIR FORCE, CAMBRIDGE RESEARCH CENTER

Conference on extremely high temperatures. Boston, Mass., March 18–19, 1958. Edited by H. Fischer and L. C. Mansur

London, Chapman and Hall, 1958. pp. xi, 258. 28 × 21cm. £3 18s.

INTERNATIONAL TELECOMMUNICATIONS UNION

List of definitions of essential telecommunication terms. Part 1—General terms. Telephony. Telegraphy

Geneva, International Telecommunications Union, 1957. pp. 300. 30 × 21cm. 23s.

JOINT COMMITTEE FOR CO-ORDINATION OF THE CATHODIC PROTECTION OF BURIED STRUCTURES

Cathodic protection of buried structures

London, Joint Committee, 1958. pp. 30. 25 × 19cm. n.p.

MEDICAL ELECTRONICS CENTER OF THE ROCKEFELLER INSTITUTE

Bibliography on medical electronics

New York, Professional Group on Medical Electronics, Institute of Radio Engineers, 1958. pp. 91. 28 × 22cm. 20s.

District Meetings

ARRANGEMENTS for District Meetings in February and March other than those in the area of a Local Centre

February 1959

HATFIELD (at Hatfield Technical College at 7 p.m., tea at 6.15 p.m.)

16 *Monday* P. R. FRANKS 'Some problems in the design of a missile-guidance system'

March 1959

MAIDSTONE (at the Medway College of Technology, Chatham, at 6.30 for 7 p.m.)

2 *Monday* J. MOIR will open an informal evening on 'Domestic high-fidelity reproduction'

OXFORD (at the Southern Electricity Board, 37 George Street, at 7 p.m.)

11 *Wednesday* R. CARRUTHERS 'Zeta'

READING (at the George Hotel, King Street, at 7.15 p.m.)

16 *Monday* D. A. BARRON, M.SC. 'Subscriber trunk dialling'

Elections and transfers

The following elections and transfers approved by the Council are effective from the 1st January 1959

ELECTIONS

Associate Members

BENJAMIN, Ralph, B.SC.(ENG.)
CHANDLER, Terence William
DE SILVA, Lakshman Lal, B.SC., B.SC.(ENG.)
GROVES, Lt.-Cmdr. Lewis Bartholomew, B.A., R.N.
MORWOOD, Colin Harry, B.E.
NAGY, Ferenc
PANG, Joseph Matno, B.SC.
REDMAN, Brig. Denis Arthur Kay, B.SC.(ENG.), R.E.M.E.
ROWLES, Maurice Bradshaw
ROY, Sailendra Kumar, B.SC.
TECSY, Miklos Laszlo Istvan, DIPL.ENG.
URQUHART, George Henry, M.A.

Associates

AXON, Frank
BATES, Eric
PARKER, John Henry
WARD, Kenneth James

TRANSFERS

Associate Member to Member

AHMED, Waquar, M.SC., PH.D.
ATTKINS, Roy James
CARPENTER, Henry George, M.A.
CLARKE, William John Frank, B.SC.(ENG.)
CODLING, Norman Henry
COX, Harold Ernest
DARWIN, John Francis Bradshaw, B.ENG.
FLOOD, John Edward, PH.D., B.SC.(ENG.)
GREEN, Capt. Philip Percival Mancha, R.N.
HAMMERSLEY, Colin
HOGG, Frederic Livingston
ROBBINS, James Arthur, B.SC.(ENG.)
THRUPP, William Frederic
WHITFIELD, George Alan, B.SC.
WHITMORE, Edward John, B.SC., PH.D.

Associate to Associate Member

ALLEN, Alaric

Graduate to Associate Member

ALEXANDER, Raymond James, B.SC.
APEAKORANG, John Atta, B.SC.(ENG.)
BECK, Ian Henry
BELL, Anne (Mrs.), B.SC.(ENG.)
BENFORD, Denis Frank, B.SC.(ENG.)
BENNETT, Roger Sefton
BLACKETT, Alan Norman Jackson, B.SC.(ENG.)
BURNS, Russell Westcott, M.SC.
CHAPMAN, Robert Francis
CHRISP, George Francis
DAVIDSON, James William
DOUGLAS, Richard Alan
ELDER, Ian McDonald, B.E.
EVERS, Antony Desmond Litherland
FOYE, James McCrea, B.SC.(ENG.)
FREEMAN, John Francis
FRY, Thomas Anderton
GOLDHAWK, Donald, B.SC.(ENG.)
GWILLIAM, Peter George Arthur
HALL, Peter Malcolm, B.ENG.
HENNESSY, Arthur John, B.SC.(ENG.)
HENRY, John Rhys
HOYLE, William Howarth Morrison
KING, Ralph Daniel Bellugue, B.E.
KIRBY, Frank Selby
KNOWLES, Kenneth, B.SC.
KNOX, Ernest John, B.E.
LAWTON, William
LLOYD, Meurig Rhys, B.SC.
LOHNING, Franklin Marius, B.E.E.
MCCORMICK, Norman Robert, B.ENG., PH.D.
MAYHEW, William Harold, B.ENG.
MOWLEM, Berkeley Alfred
NELL, Alick Iliffe
NICHOLLS, James Buxton, B.E.
NUTTALL, John Gilroy, B.SC.(ENG.)
OUTRAM, William Arthur
PATTERSON, James
PELCZYNSKI, Pawel Josef
POOLE, Roy
PYLE, Clifford Martin, B.SC.(ENG.)
RAINEY, Dennis Gerald
RIDGWELL, John Talmash Franklyn
RODDY, Dennis
RODGER, Harold Frederick
SCARR, Robert Walter Alister, B.SC.(ENG.), PH.D.
SIMMONS, Roy Howard, B.E.
SMITH, Eric Roland
TAYLOR, Denis Frederick, B.SC.(ENG.)
TAYLOR, John Rex, B.SC.(ENG.)
TIBBITTS, David Francis
UNSWORTH, George David, B.SC.(ENG.)
WADDELL, James Maclagan, M.A.
WEISS, Ernest Gerhard, B.E.
WHITAKER, Arthur John
WILLIAMS, Keble Frederick
WILLIAMS, Reginald Llewellyn
WITHEY, Douglas Walter
WRIGHT, Paul Deaville
YATES, Geoffrey

The following elections and transfers approved by the Council are effective from the 8th January 1959

ELECTIONS

Graduates

ALDERTON, Jeremy Richard, B.A.
ALI, Lt. Syed Ashraf, P.N.
ALVIN, Jack
ANYAMENE, Alphonsus Obi, B.SC.
ASHWORTH, William Geoffrey
ASPINALL, Alfred
ASPINALL, Thomas Philip, B.SC.(ENG.)
AYOOLA, Julius Layiwola
BOXALL, Derek
BRASS, Alan
BRIFFA, John
CADMAN, Henry Linton, B.ENG.
CASEMORE, Reginald Frederick, B.SC.
CHADWICK, Harold
CLARK, Derek George
CLARK, Ian MacDonald, B.E.
COWLES, John
DABNEY, Albert George
DAY, John Henry
DENTSKEVICH, Boris Vladimir, B.SC., B.E.
DOUGHERTY, Terence, B.E., M.E.
DUCKWORTH, Trevor
DUNKINSON, Harold
DURHAM, Stanley James
ELLIS, John Ceiriog, B.SC.
EMBER, Alvern Albert
FLEMING, William Wood, B.SC.(ENG.)
FLINDERS, Michael, B.SC.(ENG.)
FLOWER, Geoffrey Gwynne, B.SC.(ENG.)
FRANCIS, Edward, B.SC.
FRISCHMAN, Leopold Ladislac
GENCH, Hasan, M.SC.
GEORGE, Prince Festus
GOLDBERG, Henry Irwin John, B.A.
HARCOMBE, Thomas Lyn, B.SC.
HELY-HUTCHINSON, John Richard, B.SC.
HILL, Maurice
HOOKE, George Ralph
HOWKINS, Ronald William
JACKSON, Wilfred Leslie
JUMAH, Sabah Mohammed Ali, B.SC.
KARNIK, Pulin Hemant, B.E.
KENDALL, Haydn George
KERSHAW, Eric Wright
LAHA, Arunansu Kumar, M.SC.
LEWIS, Christopher Peter, B.SC.
LINDRE, Jaan
LONG, George Vanson, B.SC.(ENG.)
MACALPINE, Robert Cameron
MATTHEWS, Brian Vivian
MILNE, Bruce Campbell, B.ENG.
MINHAS, Mohammad Yousaf
MUIRHEAD, James
NEWCOMB, Clive Victor
NORRIS, Alan Stanley
NORTHOVER, Dennis
NWACHUKU, Michael Anagamonye, B.SC.(ENG.)
PANRUCKER, Robin Nigel, B.SC.
PARKER, William John, B.A.
PATON, Charles Jellis
PAYNE, Michael Roy
PHILLIPS, Kenneth
PICKERING, Ronald
PLESTED, Anthony Ralph, B.SC.(ENG.
PRIESTLEY, Capt. Michael Harold
RAO, Myneni Hari Prasada, B.SC., M.S.
ROBINSON, Julian Anthony, B.SC.(ENG.)
SCARTH, Brian
SHEPHERD, Eric George, B.SC.(ENG.)
SHETH, Udayan Kalyanbhai, B.SC.
SIMPSON, Fl.-Officer Hugo Rowton, B.A.
SMITH, George Raymond
SMITH, William Henry
STANSBY, Anthony George, B.A.
THARMANASON, Manikkam, B.SC.(ENG.)
THORPE, Lewis Steve
TOMKINS, David Leslie Jack
TRUMPER, John William
TURNER, George Robert
VALENTINE, Charles
WATSON, Frederick Charles Strathearn, B.SC.
WAUGH, William Smith
WEST, John Grahame, B.SC.(ENG.)
WHITE, George Alan, B.SC.(ENG.)
WILD, Edward Harold Norton
WILKIE, James Stanley Gordon
WILKINS, Wilfred Lawrence
WOODWARD, Mervyn Charles

Students

ALARIBE, Augustine S. Ahuchogu
ALLEN, Graham Hardy
ALLISON, Eric
ANDERSON, Dennis
ATKINS, Thomas Edward
ATKINSON, Janet (Miss)
BACON, David James Bernard
BAILEY, Adrian George
BALASHANMUGAN, Suppiah
BALDWIN, Brian Edward
BANSTEAD, Edward James
BARGERY, Anthony William
BARNES, David William, B.SC.
BEANEY, Michael Edward
BEARNE, Keith Paul Whineray
BEASLEY, David
BECKINGHAM, Brian Francis, B.SC.
BEESON, Douglas Paul
BEHAN, Christopher George Vincent
BENYON, Robert
BHANGU, Joginder Pall
BISHOP, Kenneth Michael
BOARDMAN, Richard Malcolm, B.SC.
BOLTON, Alan Edward
BOULTER, John Robert
BRADLEY, David Alan
BRUCE, Peter
CARLISLE, James Allison, B.SC.
CARTER, Stuart Bernard
CHERRY, Michael George
CLAPSON, Philip, B.SC.
CLEMENTSON, Christopher Stephen
COOPER, Brian Frederick, B.SC.
COOPER, Stephen Hilary
CRAEN, John David Benedict
CRUMP, Arthur Edgar
CULLUM, Garth Edgar
DARLEY, George Edward
DARROCH, Ian Francis
DAVIES, George
DEPLEDGE, Norman Geoffrey
DE SOUZA, Harold
DORAIPANDIAN, Suppiah
DOWIE, Ian James, B.SC.(ENG.)
DRIVER, Antony William
DUMOLO, Peter, B.SC.
ECONOMIDES, Dionysios Gregoriou
EL-HASHIMI, Fuad Hadi
EN, James Lee Khiu, B.SC.
EVANS, Ronald Herbert James Pugh
FARMAN, Michael Edward
FARTHING, Peter
FERGUSON, Tony
FIELDER, Lawrence Henry
FINLAYSON, John McLean
FITZ-PATRICK, Dennis
GIBBS, Roy Charles
GIBSON, David Charles
GILES, Brian Joseph
GRAY, Albert
GREEN, Michael Donald, B.SC.
GREENFIELD, Raymond Leslie
GREGG, Charles Trevor
GUDGEON, David Arthur, B.SC.
GUNN, Robert Morrison
HALE, John Malcolm
HAMILTON, Roland Douglas Monteith
HAMMOND, Francis Peter, B.SC.
HARDING-JONES, Peter, B.SC.
HARRIS, Graham, B.SC.
HARRIS, Meurig, B.SC.
HARRISON, Cecil Maurice
HARRISON, James Marcus
HASTINGS, William, B.SC.
HATTON, Edward Albert
HAWKSWORTH, Raymond
HAY, James Peter Elder
HAZLERIGG, Alexander David Grey
HEATH, Gordon Fox
HIRST, Donald Edward
HOBSON, Clifford Allan
HODGSON, Peter George
HOLMES, John Alan
HOMER, Robert James, B.SC.
HOPKINS, Evan Roderick
HORRITT, Lawrence
HORROCKS, Daniel Edward
HOWE, Colin John
HOWICK, Ronald Edward
HUGHES, Edward Thomas Elfed
HUNN, Reginald Arthur
HUNT, John Frank
HUNTER, Malcolm Gregory
JENKINS, Glyn Thomas Richard
JOHN, Ley Peter
JONES, Glyn Edward
JONES, Kenneth Graham
JONES, Trevor Vaughan

Students (continued)

KEAST, Rodney John
KENT, David Ernest
KENT, Donald Geoffrey
KHANNA, Rajindar Nath, B.A.
KILMINSTER, Robin Franklin
KIMBER, William Arthur
KING, Graham Alan
KNIGHT, Anthony Victor
KYNMAN, Richard Charles
LAIRD, Hugh James
LEE, Brian George
LEE, Brian Trevor
LEE, Derek Christopher
LEGG, Malcolm, B.SC.
LESLIE, Ian Stewart
LIM, Lee Kee
LINES, David, B.SC.
LIPPIATT, Arthur George, B.SC.
LITTLE, James
McCRAW, Ian Alexander
MACDONALD, John Burnet
MACE, Robin Hugh
MACLEOD, Donald
McWATT, Edward Jerome
MAITLAND, Thomas Barry
MANTON, Colin Brian
MARSHALL, Edward Trevor
MARSHALL, John Edward, B.SC.
MARTIN, Raymond Geoffrey
MASON, James Douglas
MASTERMAN, John Michael, B.SC.
MAYNARD, John, B.SC.
MILES, Donald Victor, B.SC.
MILLER, Ronald Charles Innes, B.SC.
MILLS, Michael Rudolph, B.SC.
MOBBS, John Charles William
MORRIS, David Bremner
MORRIS, Richard Michael
MOSES, George Edward
MOWAT, John
MURUGIAH, Vythilingam
NAKASHA, Hamid Majid
NAYAR, Prem Kumar
NEWTON, Robert Dorrick
NICOLL, William McLean
O'BRIEN, Michael Thomas
PAGE, Peter Colin
PANCHOLI, Harshad
PARSONS, Brian Alan Richard
PATEL, Jayantilal Purshottam, B.E.
PATEL, Shashikant Purushottam, B.SC.
PENNY, Michael John
POSTANCE, Brian Victor
POUND, Graham Dudley
PREST, John
PRYER, Edward Harold Percy
PRYOR, Bernard Malcolm
RACKHAM, David John
ROBINSON, Frank
ROBINSON, Geoffrey Hunter
ROGERS, William James
ROLFE, Brian Alan John
ROLFE, Derek Sidney
RUSSELL, Lawrence John, B.SC.(ENG.)
RUTHERFORD, Donald Alistair
SAHA, Narayan Chandra, B.SC.
SAMWELL-SMITH, Brian
SHACKLETON, Desmond Ebenezer
SHARP, David
SHOREMAN, Derek, B.SC.
SIMPSON, Howard
SMITH, Peter John
SONNTAG, Charles Forbes
SOUTHWELL, Barry
STANLEY, John
STARR, Brian Gordon
STEWART, Derek George
STEWART, Robert David
STICKLAND, William John
STONE, Michael Thomas
TAPPING, Peter Raymond
TAYLOR, Archibald Ekundayo
THEAKSTON, James Michael
THOMAS, Brian Hall
THOMPSON, Peter Moseley
THOMSON, Neil Worley
THORPE, Laurence Joseph John
TREND, Raymond Kenneth John, B.SC.
TWIST, Barry Hilton
VARMA, Mool Raj, B.SC.
WAFER, Ronald Vincent
WAKEFIELD, Peter Eric
WANNELL, Malcolm George Bridgeman
WARD, Edward
WARDELL, John
WATT, Henry
WATT, Nicol Lumsden, B.SC.
WEATHERLEY, Keith
WEAVER, Peter Stanley
WELLER, Clive
WELLS, Alan Raymond
WELLS, Vernon Humphrey
WESTERN, Donald Edward
WHEATON, Paul James Michael
WHITING, Richard Clare Boby, B.A.
WICKERSON, David Eric
WILLIAMSON, Rupert Keith
WILLIAMSON, Sydney Ernest, B.SC.
WILSON, Thomas
WINN, Roger Frederick Edward
WINNING, Reginald Robert
WORNHAM, Peter Ian
WRAGG, Peter John, B.SC.
WRAY, Jack
YATES, Malcolm Roger

TRANSFERS

Student to Graduate

AIRTON, Raymond Anthony
AKINLEYE, Emanuel Akintune, B.SC.(ENG.)
BARRATT, Sub-Lt. Frank Edward John, R.N.V.R.
BASTON, David Arthur Leonard, B.SC.TECH.
BAXTER, Bryan John
BAYES, Douglas Vincent, B.SC.TECH.
BLAND, Richard John, B.SC.(ENG.)
BOARDMAN, Colin, B.SC.
CARLILE, Thomas Frederick, B.SC.(ENG.)
CATHRO, James Grant, B.SC.
CLARKE, George Edmund, B.SC.TECH.
DANIEL, William Royden
FIELDING, John Graham, B.SC.(ENG.)
GOOLD, Stuart Alan, B.SC.
HARRIS, John Dudley
HASLER, Christopher, B.SC.(ENG.)
HAWKINS, Geoffrey John, DIP.TECH.(ENG.)
HEMANS-MENSAH, Henry Mark
JONES, Capt. Peter Allen Woodhouse, B.SC.(ENG.), R.E.M.E.
KAO, Kuen Charles, B.SC.(ENG.)
KHOR, Teik Hean Michael, B.E.
LANSDOWN, Peter Willcox, DIP.TECH.(ENG.)
LEONOWICZ, Jan, B.SC.(ENG.)
McMILLAN, Robert Neville Hugh, B.A.
McNEILL, Alexander, B.SC.
MALLINSON, Michael Peter Durell
MASHETER, David, B.SC.(ENG.)
MILES, John Frederick, B.SC.(ENG.)
MUSTAFA, Nouzad Majid
NEWMAN, Peter Leslie, B.SC.
NORONHA, Leonardo Gastao, B.SC.
PAGE, David Dunkerley, B.SC.
PEARSON, Rodney, B.SC.(ENG.)
QUIRK, John Hugh Gibbons, B.ENG.
REYNOLDS, John William Lucas, B.SC.(ENG.)
ROBERTS, Allan David, B.SC.TECH.
ROSS, James Derek Locke, B.SC.
SLATER, David John, DIP.TECH.(ENG.)
SPOONER, Alan, B.SC.
STANIFORTH, James Alan, B.ENG.
TAN, Kiah Tong, B.E.
TURNBULL, James George
VON KROGH, Karl
WAKEFIELD, David Colin, B.SC.(ENG.)
WILKINSON, Brian Roderick, B.SC.
WINSTANLEY, Harry, B.SC.TECH.

Contents of the current issues of the *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis

PART A. POWER ENGINEERING (FEBRUARY 1959)

S. E. GOODALL, M.SC.(ENG.), F.Q.M.C. **Inaugural Address** *January 1959*

J. K. WEBB, M.SC.(ENG.), B.SC.TECH. **Measurement and Control Section: Chairman's Address** *January 1959*

D. P. SAYERS, B.SC. **Supply Section: Chairman's Address** *January 1959*

R. A. MARRYAT, B.SC.(ENG.). **Utilization Section: Chairman's Address** *January 1959*

Centre, Sub-Centre and Group Chairmen's Addresses

PROF. F. GIORDANI. ABSTRACT 2691 S **The objective for Euratom**

PROF. M. V. DESHPANDE, B.E., M.S., AND T. R. SUBRAHMANYAN, B.E., M.E. PAPER 2757 U **New method of determining rotor leakage reactance and resistance of a three-phase induction motor** *February 1959*

C. ADAMSON, M.SC.(ENG.), AND E. A. TALKHAN, B.SC., PH.D. PAPER 2793 M **Application of transistors to phase-comparison carrier protection** *February 1959*

Discussion on **Power-system protection with particular reference to the application of junction transistors to distance relays** and **Dual-comparator mho-type distance relay utilizing transistors** before the North Midland Centre and the North-Western Measurement and Control Group

Discussion on **British Columbia–Vancouver Island 138 kV submarine power cable** before the North-Eastern Centre, the North-Western Centre, the South-West Scotland Sub-Centre, the North Staffordshire Sub-Centre, the Western Centre, the Mersey and North Wales Centre, the South Midland Supply and Utilization Group and the Southern Centre

Discussion on **D.C. winder drives using mercury-arc rectifier/inverters** before the North Staffordshire Sub-Centre and the South-East Scotland Sub-Centre

PART B. RADIO AND ELECTRONIC ENGINEERING (JANUARY 1959)

See the Journal for January 1959, p. 45

PART C. MONOGRAPHS (SEPTEMBER 1958)

See the Journal for September 1958, p. 519

Special courses in higher technology

A BULLETIN of special courses in higher technology, covering the spring and summer terms 1959 in the London and Home Counties region, has been published by the Regional Advisory Council for Technological Education. The courses are those which do not regularly appear in college calendars or prospectuses as part of a grouped course or as subjects offered for endorsement on Higher National Certificates.

The courses are mostly part-time (usually evening), but some full-time courses are included. The bulletin may be obtained from the Secretary, Regional Advisory Council, Tavistock House South, Tavistock Square, London W.C.1, price 3s. post-free.

The regional advisory committee on electrical engineering have agreed to a request of the Distribution of Courses committee that special attention be paid to the distribution of and enrolments in courses leading to Part III of the Institution Examination.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 20TH JANUARY 1959

	No. of Contributors	£	*s.*	*d.*
£1000 and over	6	6000	0	0
£100 to <£1000	30	6586	3	0
£5 to <£100	873	9223	11	5
£2 to <£5	2105	5781	12	0
under £2	24817	12986	17	7
		£40578	4	0

HONOURS AND DISTINCTIONS CONFERRED ON MEMBERS

THE names of these members of The Institution were included in the list of New Year Honours and Distinctions conferred by Her Majesty:

KNIGHT COMMANDER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

AXON, A. E., B.E. (*Associate Member*)

COMPANION OF THE MOST HONOURABLE ORDER OF THE BATH

McMillan, Col. D., O.B.E., B.SC. (*Member*)

COMMANDER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Ashdowne, Maj. H. A., B.SC.(ENG.) (*Member*)
Butement, W. A. S., O.B.E., B.SC.(ENG.) (*Member*)
Clotworthy, S. E., B.SC.(ENG.) (*Member*)
Fletcher, P. T., B.SC.(ENG.) (*Member*)
Ratcliffe, J. A., O.B.E., M.A., F.R.S. (*Member*)

OFFICER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Essen, L., D.SC., PH.D. (*Associate Member*)
Wheeler, E. F., D.L.C. (*Member*)

MEMBER OF THE MOST EXCELLENT ORDER OF THE BRITISH EMPIRE

Hogg, I. H., B.SC. (*Associate Member*)
Jarvis, W. H. (*Associate Member*)
Petrie, R. D. (*Associate Member*)
Stonehouse, M. D. (*Member*)
Walker, D. C., B.SC.(ENG.) (*Associate Member*)

In addition, the Chaplain to the Council, the Rev. C. R. Cresswell, C.V.O., M.A., was appointed a Knight Commander of the Royal Victorian Order.

50 YEARS OF MEMBERSHIP

THE Council take much pleasure in placing on record the completion of 50 years of membership of The Institution by the members whose names appear below; they first became associated with The Institution in the year 1909.

Allen, F. E.
Atkins, Maj. A. H., M.C.
Bairsto, G. E., O.B.E., D.SC., D.ENG.
Barlow, E.
Bartley, R. H.
Bellamy, L. C. F., M.C.
Bernard, G. H. B.
Biswas, P. N.
Brimelow, H. A.
Butters, Sir John H., C.M.G., M.B.E.
Cattell, G. S.
Cresswell, F. G.
Daglish, E. E.

Fifty Years of Membership (continued)

Deane, N. B.
Dennis, T. H.
Dickinson, R. E.
Dover, A. T.
Eccles, W., M.SC.
Fraser, G. Y.
Gerstenberg, F. T.
Glen-Bott, C. L., O.B.E., M.A.
Goble, F.
Gomersall, E., O.B.E.
Hann, C. S.
Hargrave, A. L.
Hartley, J. B., M.C.
Henderson, A.
Henley, F. L.
Hipwell, L. W.
Horsfield, A. H.
Huntley, C. G.
Ineson, A.
James, S.
Leak, Maj. B. W.
Leeson, Col. B. H., C.B.E., T.D.
MacDonald, G. J.
Marks, E.
May, C. E.
Metcalf, Rev. F. W. R., M.A.
Morgan, J. D., D.SC.
O'Brien-Owen, R. J.
Oxley, A. R.
Parry, W.
Payne, L. S.
Pentelow, H. P.
Peter, Maj. L. H., A.F.C., M.C.
Pitt, P. S., M.A.
Price, S. L. R.
Robertson, A. P., M.B.E.
Robinson, P. M.
Roy, N. N., M.A., B.SC.(ENG.)
Sandell, J. W. O.
Shaw, W. H.
Smellie, A.
Smith, C. H.
Sparks, A. C., M.C.
Speight, J. W.
Spendlove, S. W.
Stafford, Maj. C. S.
Thompson, C. W.
Towers, A. C.
Trencham, H.
Turner, E. F.
Tyrrell, F.
Wallis, L.
Webber, G. E. F.
Williams-Ellis, Lt.-Col. M. I.
Wood, W. W.
Wright, A. C.

DISCUSSIONS AT MEETINGS

THE Council desire it to be understood that contributions to the discussions at meetings should not be read from manuscript, since they consider that this form of presentation is contrary to the true spirit of a discussion.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

MEMBERS who are unable to be present at a meeting, or who, if present, do not have an opportunity of speaking, may submit written contributions to the discussion which will be considered for publication in the *Proceedings*. This does not apply to Informal Meetings or Discussion Meetings.

We would also remind members that written contributions on papers published in the *Proceedings* without being read at meetings will be considered for publication.

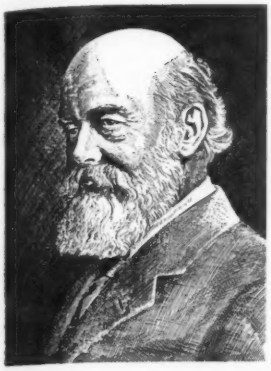
Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

ROYAL SOCIETY TERCENTENARY

THE Royal Society proposes to celebrate the tercentenary of its foundation from the 18th to 26th July 1960, and a committee under the chairmanship of Sir Cyril Hinshelwood, President of the Society, have already begun planning for this event. Leading scientists from all over the world are expected to attend the celebrations, which are to include special visits to the City of London and the Universities of Oxford and Cambridge, both of which have important links with the Society's development over three centuries.

PORTRAIT OF OLIVER JOSEPH LODGE

IN accordance with their annual custom of producing portraits of the pioneers of communication engineering, the Union internationale des télécommunications have recently issued an engraving of Oliver Joseph Lodge (Sir Oliver Lodge), a reproduction of which is shown here. Pictures in this series, which are printed on art paper, measure 23 × 17cm (including margins) and may be obtained from the Secrétariat général of the Union, Palais Wilson, 52 rue des Pâquis, Geneva, price 3 Swiss francs each, post-free. A short biography accompanies the portrait, of which 700 copies only are being printed. A small number of portraits are still available of Ampère, Armstrong, Baudot, Bell, Erlang, Faraday, Ferrié, Fresnel, Gauss, Heaviside, Herz, Hughes, Kelvin, Kirchhoff, Lorentz, Marconi, Maxwell, Morse, Popov, Pupin, Rayleigh, Siemens, Tesla and Weber.



CIVILIAN STUDENTSHIPS

STUDENTSHIPS at the Royal Military College of Science, Shrivenham, are offered each year to civilians. Those successful join young officers in courses, normally of three years, preparing for the London University degree of B.Sc.(Special) in chemistry, physics or mathematics or of B.Sc.(Engineering). Boys to whom awards are made are expected to join the Scientific Civil Service on taking their degrees.

A studentship carries exemption from payment of tuition and examination fees, and the student receives a maintenance allowance of £355 a year. No means test is imposed, and the allowances are not liable to income tax.

Candidates must be under 22 on the 1st October of the year of entry, unless they have completed their National Service, when they must be under 24. They will be selected on the basis of their scholastic record, supplemented by a written examination in mathematics, physics and chemistry.

Application forms and further information may be obtained from the Ministry of Supply, Est. 3(R)3, Room 512, The Adelphi, Strand, London W.C.2.

BRITISH ELECTRICAL POWER CONVENTION

TORQUAY: 1ST–5TH JUNE 1959

THE theme of the 11th British Electrical Power Convention at Torquay from the 1st to 5th June 1959 will be 'Electricity and its contribution to the standard of living'. The President of the convention is Mr. C. R. King, C.B.E., COMPANION. As in former years, an exhibition will be associated with the convention.

The convention sessions will be held in the Pavilion and will open on the morning of Tuesday, the 2nd June, when Mr. King will give his presidential address. According to the preliminary programme, a paper on 'Progress on the first nuclear power stations—Bradwell, Berkeley, Hinkley Point, Hunterston' will also be given on Tuesday morning by Mr. F. H. S. Brown, B.SC., MEMBER, and Mr. J. Henderson, M.C., B.SC., MEMBER.

On Wednesday morning, Mr. A. N. Irens, M.SC.(ENG.), MEMBER, will present a paper on the subject of industrial, commercial and domestic electrical progress. There will be two papers in the afternoon session—one by a representative of the Electrical Contractors' Association, dealing with electrical contracting in all its aspects, and one by a representative of the National Inspection Council for Electrical Installation Contractors, on all aspects of safety in the home.

Mr. O. W. Humphreys, C.B.E., B.SC., MEMBER, will give a paper, with demonstrations, on 'The development of light sources'.

NATIONAL SOCIETY FOR CLEAN AIR

THE Diamond Jubilee International Clean Air Conference and Exhibition will be held in London from the 20th to 23rd October 1959. The conference will celebrate the 60th anniversary of the foundation of the National Society for Clean Air, established in London in 1899 as the Coal Smoke Abatement Society.

Provisional themes of the six conference sessions are: official welcome and an inaugural address by Sir Hugh Beaver, K.B.E., President of the Society; legislation; public opinion and education; technical; international co-operation, studies and information exchange; and research and investigations.

The last day of the conference will be devoted to visits and excursions.

Further information regarding written contributions and registration may be obtained from the Director and Secretary, National Society for Clean Air, Palace Chambers, Bridge Street, London S.W.1.

MOLECULAR AND ATOMIC MOTIONS

A JOINT meeting of the British Radio-Frequency Spectroscopy Group and the Groupement AMPERE will be held in the Physics Department of Queen Mary College (University of London) on the 1st–3rd April 1959. The general subject of the meeting is molecular and atomic motions in solids and liquids as studied by radio-frequency methods.

Further information may be obtained from Dr. J. G. Powles, M.SC., D.ÈS.SC., GRADUATE, Reader in Experimental Physics, Queen Mary College (University of London), Mile End Road, London E.1.

SOME ASPECTS OF MAGNETISM

A CONFERENCE on 'Some aspects of magnetism' is being arranged by the Institute of Physics for the 22nd–24th September 1959.

The subjects to be dealt with by the conference are: fundamental theories of ferro-, ferri- and antiferro-magnetism,

including magnetic structure; theories of technical magnetization processes; and theoretical and experimental studies of domain phenomena and of antiferromagnetism.

Further particulars are available from the Secretary of the Institute of Physics, 47 Belgrave Square, London S.W.1.

AUSTRALIAN AND NEW ZEALAND ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE 34th Congress of the Australian and New Zealand Association for the Advancement of Science will be held at Perth, Western Australia, on the 24th–28th August 1959.

Among the topics proposed for section H—engineering and architecture—are acoustics of buildings, transport problems, and analogue computers. Joint symposia with other sections are being arranged on hospital buildings and hospital equipment and on nuclear energy.

Further information may be had from Mr. P. C. Massey, Hon. Secretary, Section H, 1959 A.N.Z.A.A.S. Congress, Department of Civil Engineering, University of Western Australia, Nedlands, Western Australia.

CONFERENCE ON INFORMATION PROCESSING

AN international conference on information processing will be held in Paris from the 15th to 20th June 1959 under the auspices of the United Nations Educational, Scientific and Cultural Organization.

Its main themes will be methods of digital computing; logical design of digital computers; common symbolic language for digital computers; automatic translation of languages; collection, storage and retrieval of information; and pattern recognition and machine learning.

Discussions will be led by Prof. J. Kuntzmann, University of Grenoble; Dr. M. V. Wilkes, Cambridge University; Prof. S. Gorn, University of Pennsylvania; Prof. Panov, U.S.S.R. Academy of Sciences; Dr. S. N. Alexander, [U.S.] National Bureau of Standards; and Prof. K. Steinbuch, Karlsruhe Polytechnic School.

Concurrently with the conference, and scheduled not to conflict with its plenary sessions, symposia will be held on: relationship between digital and analogue computing; use of computers for weather prediction; automatic programming; numerical analysis on computers; influence of very large memory designs and capabilities on information retrieval; logical organization for very-high-speed computers; methods for solving linear systems; linear programming; logical organization of very small computers; programming procedures; switching algebra; error detection and correction; and machine translation.

Requests for further information should be addressed to Unesco, place de Fontenoy, Paris 7.

CONGRESS AT AIX-LES-BAINS

THE Société Française des Électriciens are arranging, for the end of September 1959, a congress at Aix-les-Bains. Matters relating to electrochemistry, electrometallurgy, and hydroelectricity will be discussed at the congress. Further information may be had from the Secretary of the Society, 8–14 avenue Pierre-Larousse, Malakoff (Seine), France.

INDUSTRIAL NON-DESTRUCTIVE TESTING

THE Non-Destructive Testing Group of The Institute of Physics will hold a meeting on the theme 'What industry requires from non-destructive testing' in the Institution Lecture Theatre at Savoy Place on Friday, the 13th March 1959, at 2.30 p.m. Further details are obtainable from Mr. L. Lawrence, The Institute of Physics, 47 Belgrave Square, London S.W.1.

NATIONAL CONVENTION OF THE INSTITUTE OF RADIO ENGINEERS—MARCH 1959

NOTICE has been received by the Secretary of arrangements being made by an organization in this country for a study tour to the United States at a time convenient to persons attending the National Convention of the Institute of Radio Engineers in New York in March 1959.

If members and others who are interested in these arrangements will communicate with the Secretary, he will convey their names and addresses to the organizers of the tour.

RESIDENTIAL POST-GRADUATE COURSES IN SCIENCE

EASTER VACATION 1959

THE Department of Extra-Mural Studies of the University of Liverpool has arranged two short residential post-graduate courses for April 1959.

The first deals with the basic principles of nuclear engineering and lasts from the 12th to 18th April. It is intended primarily for qualified engineers and others who want to acquire some understanding of the problems of large-scale nuclear-power generation.

The second course, on arc and glow discharges, lasts from the 12th to 17th April and will comprise 12 lectures.

Detailed particulars may be obtained from the Director of Extra-Mural Studies, 9 Abercromby Square, Liverpool 7.

HARWELL REACTOR SCHOOL

A COURSE for senior technical executives in industry will be held at the Harwell Reactor School from the 15th to 25th June 1959.

In addition, a second course on the control and instrumentation of reactors will take place at the school from the 7th to 17th July 1959.

The fee for each course is 50 guineas, exclusive of accommodation.

Application forms and details regarding both courses are available from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

BULLETIN OF THE SECTIONS

MEASUREMENT AND CONTROL

Grid-frequency characteristics

ON the 2nd December, at a joint meeting in London of the Supply and the Measurement and Control Sections, the C.E.G.B. had an evening out, devoted, it seemed, to a demonstration of the admirable self-control long associated with the staff of that power-full body and now, presumably by their good example, exhibited by the power system itself.

It was an interesting evening, graced by both Section Chairmen and a sizeable audience with an international flavour, as befitted the subject, provided by Électricité de France and by the attendance of six visiting U.S.S.R. engineers skilled in the problems of automation.

The papers were 'Power/frequency characteristics of the British Grid system', by Dr. M. Davies and Messrs. F. Moran and J. I. Bird, and 'Power-system automatic frequency control techniques', by Mr. F. Moran. These dealt with aspects of the problems of maintaining stable frequency in large interconnected power systems in the face of load fluctuations. A combined review of the papers appears on p. 102.

The origin of the work had been a study of the particular difficulties to be expected from the original proposal to interconnect the European and British power systems by a relatively tenuous cross-Channel a.c. cable.

In investigations on the British side, some experiments had been made on a heroic scale: first, by operating the Grid in two halves tied by only one line, taking high-speed readings of the power transfer; second, by endeavouring to control each half of the Grid to give zero tie-line transfer; and finally, with the tie open to observe the frequency differences across the gap.

With the information obtained, together with other data derived from observations of the effects of tripping the single tie-line and of suddenly dropping 150 MW of plant on one side of the closed tie-line, the authors had the raw material to build up a very complete picture of the power/frequency characteristics of the British Grid.

Armed with this information, one of the authors (Mr. Moran) had gone on to tackle the development of a novel automatic-frequency-control scheme which would go beyond the function of the speed-sensitive governors which are a part of prime movers, in that it could automatically adjust the governor settings of the base-load machines, each of which would need only a relatively small regulating range.

Mr. Moran gave a valuable summary of previous practice in this not very well known field—giving the pros and cons of North American and European automatic-control installations.

He thought that the manual control of the frequency of the British Grid was good, and the case for automatic frequency control here rested on its ability to give very stable frequency with no sacrifice of the economy resulting from loading sets on an efficiency basis.

It was clear from his paper that the whole Grid, its generators and the frequency-control gear were in effect to be a gigantic servo system.

The discussion ranged over various aspects of the subject, including doubt of the economics involved; the inevitability of automation of power systems; recognition that the Scottish systems now qualified as electrically independent; the contribution of boiler thermal inertia to frequency stabilization; and the diminution in this thermal inertia as plant conditions become critical and supercritical.

Details were given of the single 225 kV tie-line between France (11 000 MW) and Germany (18 000 MW). James Watt must have rotated isochronously in his grave if he heard his centrifugal governor referred to as an expensive monument! What do these electronic people regard as sacred?

A pleasant and valuable evening was well wound up by Mr. D. P. Sayers, Chairman of the Supply Section, when, in thanking the authors, he noted what an ideal subject they had chosen for a joint discussion and also the unique size of the experimental work which had been done. H. S. P.

Control of power supply to electrified railways

VISITORS from the Institution of Railway Signal Engineers joined the Measurement and Control Section in London on the 16th December 1958 to discuss 'Modern control techniques on the railways'. It is to be hoped that they did not expect discussion of either signalling or the control of vehicles, for the title was interpreted to refer to the control of power supplies to railways and mainly to what should be provided in the central control rooms which provide the supervisory remote control for groups of substations and the corresponding track supplies.

In opening the discussion, Mr. W. J. Webb described modern practice, with special reference to main-line railways, and Mr. L. A. M. Ginger the practice on urban systems such as the London railways. Both illustrated their talks with slides showing typical control rooms and apparatus.

The uninitiated were astonished at the large size of these control rooms, walled by switching diagrams with their representations of supply lines, switches and feeders, studded with lights and telemeter indicators. To the suggestion that miniaturization might save the operators many miles of foot-slogging a day it was sagely remarked that a modicum of physical exercise kept them from going to sleep.

The discussion was continued by Mr. C. J. Barton, and the question of how many switches could properly be controlled from one control room was soon shown to be a contentious one. It seems that a total of 400–700 switches is practicable, according to circumstances, covering the control of 30–40 substations.

Mr. T. S. Pick brought a refreshing point of view by pointing out that a control room was a place where an operator and his assistant worked and pleading for windows and a view of the wider world in place of the traditional sealed rooms.

Discussion then developed, as was proper, from the established and traditional via recent innovations to the speculative. Mr. S. Hurst mentioned systems for the remote control of signalling function and rail points in which coding and decoding were done by transistors, and telemetering by a continuous scanning system which took a look, so to speak, at all the points of interest every second or two.

The discussion became lively; speakers mentioned 10^9 operations without failure on a transistor device and a possibility of future 1 kW transistors, and Mr. C. J. O. Garrard challenged the operators to say whether sufficient economic advantage could be foreseen to justify manufacturers in developing the more complex computer-like automatic systems that are now undoubtedly a technical possibility.

A refreshing breeze from the upper atmosphere was injected by Mr. P. F. Cooke, who had just come from trials of a self-landing aircraft. He compared the achievement in three-dimensional aeronautics with the still unsolved one-dimensional problem of controlling vehicles on rails without collisions and wanted to put both the block system and the use of coloured lights into limbo with the bullock cart.

This provoked an eloquent response from Mr. Tyler, who said in effect that British Railways engineers were not as green as cabbages and that the possibilities of radio and radar, voice communication with signal-boxes and remote control of trains mentioned by Mr. Cooke were all ideas that had repeatedly been explored and had not been set on one side without reason. He gave, indeed, very convincing reasons.

On a passing suggestion from another speaker that it remained only to digitalize and transistorize the passengers, the Chairman, Mr. J. K. Webb, brought a lively discussion to a close.

A. T.

RADIO AND TELECOMMUNICATION

CHAIRMAN'S REMARKS

MY good intention to write a message to appear in the January issue of the *Journal* foundered on the need to meet an early date of submission to the Editor owing to the printers' Christmas holiday.

I want here to expand the theme I sketched in broad outline two months ago and to describe in more detail the work of the three main sub-committees of the Section Committee.

Advisory Sub-Committee

The Advisory Sub-Committee consists, in addition to the Chairman, Vice-Chairmen and the two immediate Past-Chairmen of the Section, of a number of members of the Committee, who this year are Group-Capt. A. Foden, Cmdr. C. G. Mayer, Mr. J. Moir and Mr. C. E. Strong, the latter being the Council's representative on the main Committee. The present Chairman is Mr. M. J. L. Pulling.

While some of the business of the sub-committee is referred to it by the Section Committee, especially items which come through the secretarial channels of The Institution, the Advisory Sub-Committee is the source of new ideas, where the members are always looking ahead and seeking to adapt the activities of the Section to the changing needs of its membership and the rapid advances in technology.

A problem which has been exercising the sub-committee for some time is how to encourage all the growing army of electronic engineers to regard The Institution as their professional home, where they may keep in touch with the latest developments both at home and abroad. This calls for bold action which we hope will not be long delayed.

Mention has been made in earlier Bulletins of the experiments being made with the form of our evening meetings and of the sponsoring of symposia and conventions. These are the outcome of discussions originating with the Advisory Sub-Committee, and there are already indications that this policy is putting new life into our meetings and making them more useful to the membership as a whole.

Another problem that is receiving the attention of the Sub-Committee is the annual award of premiums. With the ever-increasing number of papers that are handled by the Committee and reach publication in the *Proceedings*, the task of assessing them for the award of premiums is becoming a very heavy burden on the members of the Section Committee, not only on account of the sheer volume of work involved but also because of the difficulty of comparing the relative merits of papers that are highly specialized in different fields.

It may be that a system of awards that was feasible when it was first introduced has become unwieldy, and the Sub-Committee are reviewing various possibilities of reducing the load on individual members of the Committee and of making the task a more satisfying one to those concerned.

Papers and Programme Sub-Committee

The Papers and Programme Sub-Committee is responsible for making recommendations to the Section Committee concerning the subjects for the evening meetings of the Section and for sponsoring new papers. In so doing it implements the suggestions that have come via the Section Committee from the Advisory Sub-Committee, including the technical aspects of the proposed symposia and conventions.

The sponsoring of papers is done through a system of specialized panels covering the scope of the Section under 11 different headings. The chairmen of these panels are all members of the Section Committee, while every Committee member is expected to serve on one or two of the panels.

The Papers and Programme Sub-Committee consists of the panel chairmen and the officers of the Section and is at present under the chairmanship of Mr. T. B. D. Terroni. Mr. J. K. Webb, the present Chairman of the Measurement and Control Section, serves as its representative in view of the close association between the Sections.

An attempt to ease the problem of the premium awards has recently been introduced by getting each panel in the first instance to assess the papers coming within its scope. The panel recommendations are then considered by the Papers and Programme Sub-Committee, whose selections are presented to the Section Committee in the hope that they will be adopted with little or no modification for passing on to the Papers Committee of the Council.

Social Sub-Committee

Mr. Terroni is also the chairman of the Social Sub-Committee, which carries out the general wishes of the Section Committee in arranging the various social events of

the Section year. Most of these are now long established, such as the dinner-dance held jointly with the Measurement and Control Section and the outing to some establishment that provides both technical and social fare for members and their ladies. From time to time the pattern changes, as with the introduction of the summer visit abroad.

CHAIRMAN'S REMARKS

FOR some years it has been the practice of the Section to hold a Graduate and Student Section evening during the latter part of each session, with a view to encouraging the attendance of Graduates and Students at Institution meetings.

In furtherance of this idea, the London Graduate and Student Section have been invited to participate in a joint meeting with the Utilization Section in the Institution building on the 12th March, when the following papers will be presented and discussed: 'Coal-mining and electricity', by A. P. Foster, B.Sc.; 'Electric drives in the paper industry', by P. D. House, B.Sc.(Eng.); and 'Standardization and simplification of switchgear', by M. J. L. Willison.

These papers have been selected as being of special interest to the Section, and it is hoped that the authors will be well supported by their fellow Graduate and Student members. On this occasion the vote of thanks to the authors will be proposed by the Chairman of the London Graduate and Student Section.

It has been decided that the Section Summer Visit should be held this year at Bournemouth during the week-end of the 1st to 3rd May, commencing with a social function on the Friday evening. On the Saturday there will be visits in the Southampton area, and the meeting is expected to terminate with luncheon in Winchester on the Sunday. Further details will be announced as soon as final plans have been made, but in the meantime members may wish to note the dates arranged.

R. A. MARRYAT

It will be recalled that last year the venue was Paris and the year before Holland. This year the suggestion has been made and adopted that this four-day visit should be alternately at home and abroad, and plans are accordingly in hand for a visit somewhere in England, though it is too early for me to indicate the probable area.

G. MILLINGTON

UTILIZATION

Sparks and arcs

WHEN a high-voltage surge produced by a lightning stroke or by a switching operation sparks over an air-gap on a transmission system, the 50c/s power current may follow the spark and cause a power arc with a consequent system outage.

The conditions in which a spark initiates a power follow-current have been studied by Prof. F. M. Bruce and Dr. L. L. Alston at the Royal College of Science and Technology, Glasgow, and are described in the papers on 'Investigations of power-follow-current phenomena using a synthetic power source' and 'Impulse initiation of arc discharges' which were read and discussed before the Supply Section in London on the 26th November 1958. The papers are reviewed on p. 100.

The speakers taking part in the discussion could be broadly divided into two groups: physicists revelling in glow–arc transitions and energy balances, and engineers who were looking for data to help them in transmission-system operation.

The engineers were well aware that the number of breakdowns due to lightning on a transmission system is kN, where N is the number of lightning strokes to the line and k is the fraction of these which initiate power follow-current. Unfortunately this does not help much as nobody knows the value of N within about 500%, and the authors were unable to give any general guidance in regard to the value of k.

It was also mentioned, and the authors fully appreciated the point, that the synthetic test methods employed did not fully simulate the conditions on a transmission line; the phase of the 50c/s voltage, the line impedance, and the wind velocity could have important effects.

In thanking the authors for their papers and for presenting them so lucidly, the Chairman concluded the meeting happily by pointing out that, although there had been some references to indigestible data, indigestible food was often most pleasant to the taste.

J. S. F.

SUPPLY

Happy ending to 1958

THERE can rarely have been a more pleasant meeting than that on the 17th December, when Messrs. E. P. G. Thornton and D. H. Booth presented their paper 'Design and performance of the Gas-Filled cable system' to the Supply Section in London. A short review of the paper appears on p. 98.

There was a large audience with over 20 contributions to the discussion, the number being limited only by the time available. This is not at all uncommon when a paper on high-voltage cables is being read, but there were two unusual features about this meeting.

The first was that the Chairman, Mr. D. P. Sayers, was completely successful in persuading speakers in the discussion to keep within the time allotted to them. In consequence, a number of regular contributors, who are normally unquenchable, conscientiously obeyed the signals and gracefully extinguished themselves.

The other unusual feature was the general atmosphere. It is not certain whether this was due to the proximity of Christmas or to the lead given by the respected engineer who opened the discussion on a theme involving Santa Claus and finished with a nursery rhyme modified to suit his argument.

Whatever the cause, there was little of the open criticism which is expected when cable makers and cable users meet together. What controversy there was could be detected only by innuendo or inflexion. Among the cable makers, friend was practically indistinguishable from foe, and among the users there was competition between Divisions and Boards for 'firsts' or 'mosts'.

The dominant theme was that operational experience showed that the cable system is successful and that any defects exhibited have been put right, or could be dealt with in the future, always provided, of course, that the cost could be reduced at the same time.

Special mention should be made of the contributions to

the discussion by M. R. Tellier of Électricité de France, who was present, and by Dr. Gazzana-Priaroggia of Milan, whose written statement was read by one of his colleagues in this country.

As for the paper itself, its London presentation no doubt benefited from rehearsal in the Provinces, and it was admirably introduced by Mr. Booth in faultless style. He explained the ways in which the Gas-Filled cable differs from other types and described the improvements which have been made possible by research and systematic development.

The slides which he showed were probably all very good; but it is fortunate that the text hardly needed them, because more prolonged display would have been required for the audience really to comprehend any but the simplest of them.

In replying to the discussion Mr. Thornton, who because of shortage of time was quite unable to deal with the scores of points raised, made the best use of his short stay at the rostrum by dealing with a few selected topics which he was clearly quite determined to drive home, question or no question.

A. L. W.

LONDON REPORT

DISTRICT MEETING AT READING

Electricity supply in America

AT the second and well-attended meeting of the session, on the 24th November, Mr. W. F. Sands took the chair when Mr. R. H. Abell gave a talk, liberally illustrated with colour slides, on 'American electricity-supply practice'.

Mr. Abell prefaced his talk by remarking that in the United States electricity has two redoubtable competitors, natural gas and oil, and that consequently electricity for space heating, compared with its extensive use in Britain, was something of a novelty. Partly as a consequence of this competition, there was a progressive and virile commercial policy in every electricity undertaking.

He remarked that a surprising number of distribution systems from 2 to 15kV operated unearthed, which had certain advantages.

Low-loss iron had been applied to reduce the weight of transformers to enable larger sizes to be accommodated on single poles. Voltage regulation was generally obtained by power-plant busbar control, with regulators on the distribution networks. There were, of course, exceptions to this, but a surprising number of large transformers had no on-load tap-changing.

Mr. Abell said that the reactive component of the load was presenting serious problems, and much of the compensating capacitance was being provided on the distribution networks by using pole-mounted condensers in 40–60kVAr banks.

Completely automatic pulverized-fuel-fired power stations were beginning to make their appearance, where the only personnel to be seen was an occasional supervisor. The small number of employees in power stations generally was a noticeable feature.

On the subject of system planning, Mr. Abell mentioned that one striking conclusion reached by the engineers of one of the large companies was that 138kV transmission with maximum-size conductors satisfied the requirements up to system loads in the neighbourhood of 10000MW. Beyond this figure, the economies resulting from the use of the large conductors and 138kV transmission were exhausted.

A special feature of the close supervision exercised over power systems was the day-to-day study of circuit loadings, which provided continuous monitoring of the system voltage and short-circuit current conditions. This was a great help in distribution planning and avoided complaints from consumers.

Rural electrification had made great strides, and some differences from British farm practice which Mr. Abell noticed were the extensive use of forced ventilation, better lighting standards and the collection of milk by tankers direct from the cooling equipment. The frequent use of case studies by metering separate items of plant and the selection of a number of farms as demonstration farms were important factors in the rapid advance of farm electrification.

Considerable emphasis was being placed on the maximum carrying capacity of overhead conductors, and it was pointed out that the maximum current that could be carried without loss of mechanical strength increased 25% for a 3m.p.h. wind, as compared with a 1m.p.h. wind. The latter is the common standard in this country but is a velocity very rare in practice.

In the United States the use of aluminium or steel-cored aluminium conductors is becoming almost universal, and compression-type joints are replacing all other types. Centralized overhead-maintenance organizations are being used, with control rooms and communication systems comparable with our system control centres.

X-ray equipment for testing the condition of wood poles had been used in the field on an experimental basis, and single wood poles had been employed for carrying double-circuit 140kV lines. The main objection to this type of construction is the multiple stays at angle positions, but on straight parts of the route considerable economy can be effected.

Multiple-circuit towers with up to six circuits per tower for 140kV work were being used to avoid the multiplicity of lines leaving high-voltage substations. It was the practice in some parts to use cable entries on the lower voltages to improve amenities near substations. Driven earth rods were very widely used and to a great extent have replaced the counterpoise type of earth.

Extensive use of fuses up to 46kV on transformers up to 5MVA was a feature of distribution substations, and very considerable use was made of automatic-reclosing circuit-breakers to maintain continuity of supply.

The latest experiment in substation construction was the employment of aluminium sections, which enabled substations to be erected in a very short time, four men being able to handle quite easily the largest fabricated component in the structure of a 140kV substation. Preformed steel, designed somewhat on the Meccano principle, with the several parts assembled on the ground, was used by several companies.

Many questions were asked by members during the discussion that followed; and the meeting was closed after a sincere vote of thanks, proposed by Mr. E. W. Weaver, which was carried unanimously.

P. J. B.

ORDINARY MEETING

New methods of controlling London buses

THE chair at the Ordinary Meeting on the 6th November was taken by the President, Mr. S. E. Goodall, who opened the proceedings by welcoming new Corporate members. A Measurement and Control Section paper (2758) by T. S. Pick and A. Readman, entitled 'Recognition of moving vehicles by electronic means', was then presented. It is possible that the title of the paper may have aroused some apprehensions that a new method of detecting speeding motorists was to be unfolded, but these fears were dispelled when Mr. Pick, in introducing the paper, explained that it was concerned solely with the control of London Transport buses. A short article based on the paper appears on p. 95.

There are some 7000 buses operating on approximately 500 routes in and around London, and there is no effective centralized control giving an over-all picture of the position of these buses at any moment. Checking of buses is carried out by inspectors along the routes, but serious delays due to congestion sometimes occur. The inspectors' records can only be interpreted after a considerable lapse of time and effort and contribute little to effective control.

A new method of control has been developed in which each bus is fitted with a code plate, which can be read by a photo-electric device mounted at the roadside. The bus position is transmitted over a telephone line to an indicating board at a central control. So far the system has been installed for trial purposes on the 74 route only. The operation of the system was described with the aid of lantern slides and some excellent working models.

Many users of bus services have rather strong feelings about them, and the ensuing discussion was both lively and interesting.

The discussion was opened by Mr. C. C. Inglis, who stated that a similar scheme had been considered for British Railways. In this case, however, approximately half a million wagons would have to be controlled, and the problem is to devise means of handling the vast amount of incoming information, which might amount to 1 500 000 signals in 24 hours.

Mr. A. R. Enshaw expressed doubts over the ability of the photo-electric system to cope with weather hazards, such as fog, and stressed the necessity for reliable all-weather operation. His heartfelt wish that the author's work would improve his home-going bus service met with a sympathetic response from the meeting. Mr. B. H. Harbour made it clear that the need for improved communication and control has been obvious to London Transport for many years, service irregularity being all too common. The system should lead to improved control, but complete reliability is essential, for any failure in a centralized control would be disastrous.

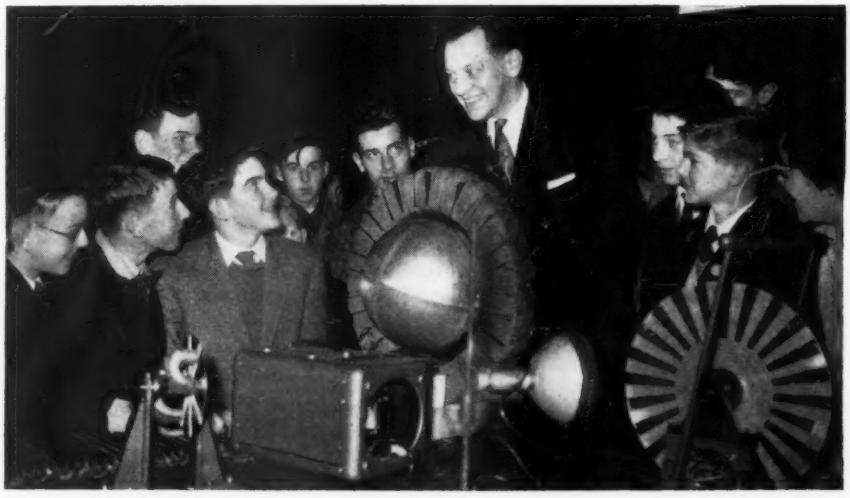
Subsequent speakers were in general agreement as to the necessity for such a control system. Mr. D. F. Nettell suggested that at the moment the passage of buses is a purely random event. Mr. P. F. Cook pointed out that the obvious solution, which is to keep motor cars off the road, might not be generally acceptable. He wondered how the bus crews would react to this system. Will they feel they are being spied on and develop means of dodging the system?

The high spot of the evening was probably the sparkling contribution by Mr. G. Millington, who clearly reflected some users' views. He suggested that intending passengers are even more anxious than the controllers to know where the buses are, and an indication at bus stops would be ideal. Even more welcome would be a warning that it is quicker to walk when it is the intention of the bus drivers to crawl.

Mr. A. Readman, in his reply to the discussion, stated that full information on the reliability of the system was not yet available. He did not think that the derived information could be made available to the passengers because of the cost: too much information might result in the loss of more passengers.

A vote of thanks by Mr. J. K. Webb closed a very enjoyable evening. We can be sure that he expressed the wishes of the nation when he hoped the day would soon come when this system is in operation on every London, and provincial, bus route.

F. C. W.



After the Christmas Holiday Lecture in the Institution building on the 1st January 1959. Dr. E. R. Laithwaite, the lecturer, is the centre of a group of schoolchildren eager to learn more about his subject of 'Invention and new machines'

DISTRICT MEETING AT OXFORD

Grid and Supergrid

ONCE more a capacity audience gathered at the showrooms of the Southern Electricity Board, Oxford, on the 12th November, to hear Mr. W. Casson present a paper on 'The development of the Supergrid system and its control'. Seventy members and guests were present, under the chairmanship of Mr. J. L. Taylor.

Mr. Casson held the interest of his audience throughout a very able discourse, starting with the development of the 132kV Grid system from its inception and showing how the seven regional schemes were developed into a national scheme. He then surveyed the national problem, related to geographical location of fuel sources, relative costs of electrical transmission and coal transport, and the impact of these factors on the development of nuclear power stations. An over-all picture of the present and probable system became clear to all those present.

Mr. Casson then considered the construction features of the new Supergrid system and its national control. It was obvious that Mr. Casson was a master of his subject, and at the conclusion of his talk everyone appreciated the numerous factors that entered into developing the national Grid and Supergrid systems into such an efficient whole.

Testing the lecturer

Following refreshments, the lecturer was tested by a variety of questions, ranging from attenuation of telephone lines to the termination equipment of the cross-Channel cable, and an enthusiastic discussion had to be terminated to allow Mr. Casson to travel north for further engagements.

A vote of thanks proposed by Mr. O. E. Manier of the Military College of Science was enthusiastically supported.

The record attendances at the first two meetings of the session augur well for the District Meetings, and the organizing committee are encouraged to hope that the trend will continue. J. L. T.

NEWS from the Centres

NORTH-EASTERN CENTRE

Social responsibilities

AT the first meeting of the new session, held on the 13th October 1958, Mr. T. W. Wilcox formally vacated the chair in favour of the new Chairman, Mr. A. T. Crawford.

In his Address, Mr. Crawford focused attention on a subject which, unfortunately for the profession, has received too little regard in the past. He dealt at length with the technical requirements and public obligations of engineers—particularly the engineer's responsibility to society—and emphasized the need for the engineer to take an active part in public life.

The next week saw the first meeting of the session of the Radio and Measurement Group, on the 20th October, with the Address by the new Chairman, Mr. G. H. Hickling. His theme was 'Research for electric power', and he dealt with various aspects of the work carried out by an industrial electrical research laboratory—covering subjects as diverse as transistors and turbines. The Address was illustrated by an excellent series of colour slides.

At this same meeting we welcomed a new Honorary Assistant Secretary, Mr. W. B. Dotchin, who had filled at short notice the vacancy caused when Mr. R. F. Cockburn left the Newcastle area. A later meeting provided the opportunity for a small presentation to be made to Mr. Cockburn in recognition of his service to the Group.

This year the informal meeting was in the first half of the session instead of in the second as hitherto. On the 12th December 1958, Mr. J. Blears, of Metropolitan-Vickers Electrical Co. Ltd., spoke about Zeta. The 75 members present were treated to a most interesting discourse and, in addition to hearing about Zeta, learnt something of the progress in thermonuclear research in the United States and the Soviet Union. Amusement was caused by the nicknames such as 'kink', 'sausage' and 'barley-sugar' applied to various types of discharge instabilities in Zeta. The ensuing discussion showed the considerable interest of local engineers in a novel aspect of electrical engineering.

Two visits took place in December, the first being on the 17th, when a party of 28 members were shown the new cathode-ray-tube factory of Siemens Edison Swan Ltd. at Sunderland. The second visit, on the following evening, was to the optical-instrument factory of Sir Howard Grubb, Parsons and Co. Ltd., at Newcastle upon Tyne, when 18 members were present.

Both visits were greatly enjoyed by those who took part. The difference between the two factories could hardly have been more marked, the first being laid out for mass-production techniques while the second worked largely on a 'one off' basis. A measure of the popularity of these visits is that, owing to the large number of applications received, duplicate visits had to be arranged in both instances.

The attention of members is directed to the Annual Dinner and Dance, the only event to which ladies are invited, which will be held on Friday, the 13th March. We look forward to a visit on this occasion by the President, Mr. S. E. Goodall, and Mrs. Goodall. F. C. P.

NORTHERN IRELAND CENTRE

Above and below the surface

THE opening meeting of the 1958–59 Session was held on the 14th October 1958, when the incoming Chairman, Dr. D. S. McIlhagger, delivered his Inaugural Address on 'The insulator surface'. A suitable subtitle for the address might have been 'It's deeper than you think', for the new Chairman stressed the complexity of the surface and reviewed, rather critically, research work by chemists and engineers, over the past half-century, on surface adsorption, absorption, conduction and breakdown. He deplored the seeming indifference shown in the past by engineers to the work of chemists, and vice versa, but hoped for more collaboration in the future.

That no discussion should take place is of course the standard form, and, in proposing the vote of thanks, Maj. J. E. Jones avoided this by leaving the surface entirely. Instead, he dealt in characteristically lighter vein with the qualities which lead to Centre chairmanship and gave a statistical analysis of the incidence of those qualities as evidenced in the history of this Centre.

The Press, too, later left the surface and became airborne, for they concentrated almost exclusively on the Chairman's concluding remarks about atmospheric pollution and our responsibility for its abatement.

An informal lecture by Mr. C. M. Snowden, on the 11th November, had the rather ambiguous title 'Digging up the past'. Mr. Snowden made it clear at the outset that he was going to talk about the history of our science and not about archaeology. His theme was that if Faraday's work on the dynamo had not received so much attention from engineers, other electrical-energy sources might have been less sadly neglected.

Mr. Snowden covered the history of some of these devices, and the story of the fuel cell and its present state of development proved especially interesting. The discussion (invited by Mr. Snowden) rather left the rails, so that the house almost divided on whether Michael Faraday was the 'father of electricity'. It can be said, without prejudice to the lecturer (who did not suggest otherwise), that a large majority allowed the paternity claim.

At the December meeting, on the evening of the 8th, Mr. F. Mather dealt with 'The earthing of low- and medium-voltage distribution equipment'. The paper was one of those extremely rare ones, eagerly sought after by papers committees, which are eminently suitable for delivery at any Centre. The discussion which followed its presentation showed that everyone present had a keen interest in earthing—as consumer, contractor or supplier. The discussion, too, showed that nearly everyone was convinced that only one form of earthing was safe, cheap and simple—his own method.

Some references in the paper to the electrical consequences of high resistance at an earth electrode led to a question whether worms choose an equipotential path and move thereafter in concentric circles about the faulty electrode. While this seems an excellent method of causing the most reluctant worm to turn, the question was probably the only one left unanswered by Mr. Mather. The meeting lasted three hours, which, when considered with the attendance, must have led to an all-time man-hour record. D. S. M.

MERSEY AND NORTH WALES CENTRE

Power-system problems

THE lecture given by Messrs. C. H. Lackey and A. G. Crawford in Liverpool on the 5th January 1959, on 'Circuit-breaking and power-system problems', admirably complies with the call for papers of specialist interest presented with a general appeal.

Through the good offices of Prof. A. M. Meek, the lecture theatre of the Donnan Laboratories of the University of Liverpool was made available for this meeting, and an audience of 180 were entertained and intensely interested by the demonstrations and exposition—presented in somewhat unusual fashion by the authors speaking in relay.

District Meetings

District Meetings in the first half of the session have been held in Warrington and Wrexham. In the former town, Mr. J. Collins repeated his Chairman's Address on the 12th November, and four weeks later Mr. D. A. Picken discussed 'The annual report on electrical accidents'. The meetings were well attended, and a large measure of the success of such District Meetings is due to Mr. Picken and also—in previous years—Mr. P. W. Cave, for their willingness to present informal lectures on matters of great importance to the members.

Busbar protection?

At the Wrexham meeting in the Talbot Hotel on the 28th November, Mr. R. W. Newcombe lectured on 'Busbar protection'. That the title of the lecture and the location proved attractive was demonstrated by the attendance of 47 members and visitors.

The photograph emphasizes the necessity for care by an author when selecting a title for his paper—and perhaps provides a hint to conveners of similar meetings. E. W. A.

NORTH MIDLAND CENTRE

Annual Dinner

THE Annual Dinner was held at the Queen's Hotel, Leeds, on the 14th November 1958 and was presided over by the Chairman, Mr. J. D. Nicholson. Once again we were honoured in having the President as our guest. The function was attended by 269 members and guests and proved a most successful evening.

The Rt. Rev. G. W. Clarkson, Bishop of Pontefract, proposed the toast of 'The Institution and the North Midland Centre'. This toast was given in a very witty style—comparing the parallel works of electrical engineering and the Church; each strives to ensure that truth may be more widely known and to promote ideas for education, wealth and welfare. The Institution and the Church had parallel ways of serving the

In this group, at the Annual Dinner of the North Midland Centre on the 14th November 1958, are (l. to r.) Mr. S. E. Goodall, the Rt. Rev. G. W. Clarkson, Bishop of Pontefract, Mr. C. W. Brasher and Mr. J. D. Nicholson

public, but the cost of very many years of devoted service could not always be counted in terms of money.

The President, Mr. S. E. Goodall, in response said that we realized our responsibilities and were proud of the industry we served. He also referred with pleasure to the goodly proportion of younger men present and appealed to the older members to encourage youth as much as possible, saying that the virility of The Institution depended on young men coming forward.

The toast of 'Our Guests' was proposed by Mr. Nicholson, who in a graceful speech said that in the past we had had the good fortune to have many distinguished guests and this year was no exception. After briefly mentioning individual qualities of many of the guests, he referred to the element of youth represented by Mr. Chris Brasher.

He described Mr. Brasher, sen., as a guide, philosopher and friend to a succession of Presidents and pointed out that on this occasion he also appeared as part-owner and trainer of an Olympic champion.

In an amusing reply, Mr. Chris Brasher contrasted the attitude to sporting events in Russia and in this country and showed how different were the results obtained with State-organized and with commercial recreation. He appealed for more opportunities for recreation, particularly for the younger folk, to combat some of the modern social evils and concluded by remarking that welfare is sometimes more important than the pocket.

Conventional and nuclear power stations

Approximately 70 members were present on the 2nd December at the third ordinary meeting held in Leeds. The meeting was opened by Mr. J. D. Nicholson, who welcomed two new Corporate members and explained to them the aims of The Institution.

He then introduced the speaker, Mr. K. L. Stretch, who presented his paper on 'Operational experience at Calder Hall'. Mr. Stretch referred to his experience in the development of nuclear power and his recent transfer to the production of older forms of fuel. We could therefore expect to hear the best of both worlds.

A lively and interesting discussion followed the paper, with many speakers taking part. Among the varied comments one perhaps pertinent query was whether it was high-level Government policy in engineering development to transfer the country's best brains back to the basic fuel industry. Mr. Stretch naturally made no comment in this connection, but current conditions suggest it might not be a bad idea.

Some indication of the popularity of the paper can perhaps be obtained from Mr. Stretch's opening remarks in replying to the discussion—to the effect that if the audience were prepared for an all-night session he could answer all the questions which had been raised.

In proposing a vote of thanks, Mr. Nicholson commented on the able and detailed way in which Mr. Stretch had replied to the many questions and said that he had gained a much clearer understanding of the problems of nuclear power stations and their position in the national economy.

Reheat practice

On the 11th December a joint meeting was held with the Institution of Mechanical Engineers, Mr. E. N. Taylor being in the chair. In opening the meeting he remarked that this was the first joint meeting which had been held for some considerable time and expressed the hope that it would be such as to encourage the holding of joint meetings between the two Institutions more frequently.

Mr. Taylor then asked Mr. F. H. S. Brown to read his paper on 'Reheat practice in British power stations'. Mr. Brown did so with characteristic efficiency, and underlying his remarks his enthusiasm for the larger fossilized-fuel turbogenerator plants was most evident. His ideas in this respect were, to a very large degree, confirmed by the remarks of Mr. C. G. Richards, who opened the discussion.

Mr. Richards based his comments on experience already obtained with the 100 MW sets installed at Ferrybridge power station, which left him in no fear of the performance of the 550 MW sets to be installed in Yorkshire in the near future. This notwithstanding the fact that he is now finding the cost of water for these stations approaching the price of beer.

Mr. Brown replied most adequately to a number of other speakers on various points from an audience of approximately 100. In proposing a vote of thanks, Mr. J. D. Nicholson thanked the author for a stimulating paper and the Yorkshire Branch of the Institution of Mechanical Engineers for inviting the North Midland Centre to take part in the meeting.

Grid-control facilities

The fifth ordinary meeting was held on the 6th January 1959. The Chairman, Mr. J. D. Nicholson, opened the meeting by referring to the attendance of 110 members and said how heartening it was to see so many people present in view of the bad weather conditions. He welcomed a new Corporate member and spoke to him of his individual obligation to The Institution.

Mr. Nicholson then introduced Mr. P. F. Gunning, who was reading his paper on 'Standardization of control facilities for the British Grid: communications, indications and telemetering', and Mr. C. H. Chambers, co-author with Messrs. C. A. Burns, F. Fletcher and P. F. Gunning of the paper on 'The development of communication, indication and telemetering equipment for the British Grid'.

The two papers were presented in a most interesting

fashion, together with slides and demonstrations. There followed a very full discussion, which was replied to in an able and lively manner by Mr. Gunning. In thanking the authors the Chairman referred to them as two having been closely connected with the telecommunication side of the industry since its inception and congratulated them on their balanced account of these interesting developments.

Utilization Group

The second meeting of the Utilization Group was held in Leeds on the 18th November 1958 under the chairmanship of Mr. A. R. Rumfitt. The paper read was entitled 'Electrification of the U.K.A.E.A. Industrial Group factories' and covered some interesting problems in supply to and distribution in the factories—complicated by the nature of the product and the magnitude of the load demand.

The joint authors were both present; Mr. J. W. Binns read the paper, and Mr. W. J. Outram replied to the discussion. The attendance was 48 members, of whom many took part in the discussion. At the end of a successful evening the chairman proposed a vote of thanks, which was carried with acclamation.

Catterick District Meeting

On the 11th November 1958 about 80 members and visitors attended a meeting at the School of Signals to hear a lecture by Mr. P. L. Taylor entitled 'Man and machine—10000 years of automation'. The meeting was opened by Lt.-Col. M. A. Philp, who welcomed the Chairman and other visitors. He gave a special welcome to visitors from Leeds, Manchester and London—including Prof. E. Bradshaw, who was attending the Catterick meeting for the first time. Lt.-Col. Philp then introduced the lecturer and stressed the importance of modern techniques of automation and computing to every branch of the electrical-engineering fraternity.

Mr. Taylor traced a continuity of progress from the first flint knives of prehistory to the tools of today, quoting among other examples full automatic profile-milling machines and electronic translators. He explained how the three necessary functions provided by slaves in early times were interpretation of commands, supply of energy (store), and control of energy and showed how each of these functions was gradually handed over to machines.

An informal interlude at the Catterick District Meeting on the 11th November 1958

The lecture was a model of clarity and was well illustrated by slides and by working models. Wing-Cmdr. Lewis, who opened the discussion, was relieved to find that the machines still needed some controlling hand and that he was not yet redundant. He asked what the future held for the labourers replaced by the new machines. Mr. Taylor replied that we must educate our children up to the new kinds of skills required of them.

Further questions revealed that computing machines could help in the task of digesting and sorting the ever-growing harvest of technical literature that threatens to overwhelm the busy office-worker and that the native conservatism of the English businessman would ensure that these expensive machines would only be used on worthwhile jobs. The tendency was for libraries of sub-ventures to be built up so that even relatively short tasks were becoming more and more economic.

In answer to Col. R. G. Miller, Mr. Taylor said that experiments based on the hypothesis that certain brain functions are similar to the operations of a computer had been carried out with the aim of proving the hypothesis, but so far no conclusive results had appeared. Lt.-Col. Philp closed the meeting and thanked the lecturer for a most enjoyable and interesting talk. After the meeting, electrical engineers found their way to their cars in a black downpour of rain, guided by an old-fashioned flare-path of hurricane lamps.

W. J. W.

NEWS from abroad

ARGENTINA JOINT OVERSEA GROUP

Strike affects dinner

ON the 2nd September 1958 a well-attended meeting of the Group was held at which Mr. D. R. Parker gave a commentary, illustrated with colour slides, on the construction of Portishead 'B' power station.

Mr. G. F. Kennedy, who was making an extensive lecture tour through Canada and South America following the World Power Conference in Montreal, gave us the opportunity on the 22nd October of hearing about his experiences. About 50 members and friends were present.

The Annual General Meeting of the Group was held on the 27th November, followed by a showing of films of engineering interest. An informal dinner took place afterwards, but unfortunately, owing to the inclement weather and a general railway strike, this was not so well attended as usual.

A. C. T.

MIDDLE EAST JOINT OVERSEA GROUP

A walk along the pier

THE 1958–59 Session began on the 4th December 1958, when a Past-Chairman, Mr. J. D. Addison, in the absence of the retiring Chairman, Capt. J. M. Morris, delivered the Chairman's Report on the activities of the Group during the last session and installed Mr. L. J. Cotterill in the chair for the current session.

In his opening Address Mr. Cotterill dealt very ably with some of the great engineers and inventors of the past. His theme was that these men were instruments by which progress

was made and that to them we owed many of the amenities of our life today.

A vote of thanks to Capt. J. M. Morris, proposed by Col. K. D. Phelps, was carried by acclamation.

A visit on the following day to the new North Oil Loading Pier—at present being constructed by the Kuwait Oil Co.—was attended by 24 members and guests. We are indebted to the management of the Kuwait Oil Co., Messrs. Rendel, Palmer and Tritton, and George Wimpey and Co. for an excellent and interesting visit around this new pier.

This is an all-welded steel structure 2300ft long, nearly a mile from the shore, which has been designed to take tankers of the 100000-ton class. The present construction caters for five berths, although if two 100000-ton tankers are berthed at one time there will be berthing capacity for only four tankers. The depth of water available at the pier head is 55ft.

The visit was followed by an excellent lunch at the Hubara Club, Ahmadi, Kuwait. D. W. P.

QUEENSLAND OVERSEA COMMITTEE

Christmas Luncheon

THE Annual Christmas Luncheon was held on the 11th December 1958 at Manhattan Gardens and was attended by 37 members and one guest. It is customary to invite a guest from outside the electrical-engineering profession, and on this occasion we were able to welcome Mr. D. W. Fraser, the Queensland Public Service Commissioner.

After the loyal toast, the Chairman, Mr. Faulkner, proposed Mr. Fraser's health. In a short reply, Mr. Fraser took as his subject 'Public service'. He traced its growth through the development of modern civilizations and stressed the fact that it is never the intention of the public service to initiate or dictate policy but rather to implement policy directed from ministerial level in the interests of the community generally. He commented on the kinship between public service and engineering institutions, in that both are capable of considerable service in any civilization.

A vote of thanks to the speaker, which was proposed by Prof. S. A. Prentice, was carried with acclamation. Mr. J. S. Just proposed the health of the Chairman, who had given many years of service to The Institution, both on the Committee and in his present capacity. Mr. Faulkner briefly replied, and the luncheon terminated with exchanges of greetings among those present. W. I. G.

SOUTH AUSTRALIA OVERSEA COMMITTEE

'The restless sphere'

A LADIES' NIGHT, the first for several years, was held on the 27th November 1958 and proved a fitting climax to a successful session. The evening began with a buffet dinner, attended by 30 members and their ladies, after which the brief formal business of the Annual General Meeting was transacted. This being completed, Mr. A. J. H. Oxford, our Chairman, introduced our guest, Mr. E. D. Treharne, a principal scientific officer at the Weapons Research Establishment.

Mr. Treharne briefly introduced the B.B.C. telefilm 'The restless sphere', a copy of which had been lent for the occasion by Amalgamated Television Services Pty. Ltd., Sydney. In this most interesting film, recorded directly from the programme televised by the B.B.C. on the 30th June 1957, H.R.H. the Duke of Edinburgh ably introduces speakers and scenes in England and abroad, describing the work to be undertaken during the International Geophysical Year, which began that night. Some of those present recognized colleagues in scenes showing the preparation and firing of a Skylark rocket at Woomera.

After the film, Mr. Treharne outlined some of the achievements of the International Geophysical Year and the contribution made by Australia. So ended the evening, our enjoyment of which was marred only by the heat, as much a failing of our climate in late November as fog is of London's.

We are especially grateful to Mr. Basil Sands of the B.B.C.'s Australian Office for finding a 16mm copy of 'The restless sphere' and for arranging the loan.

Looking back

A feature of 1958 was the introduction of some extra meetings of a more specialist appeal than has been usual in the past. On two occasions we were fortunate in hearing speakers who had been delegates to The Institution's conventions on navigational aids and on microwave valves held in March and May 1958. Mr. J. E. Clegg spoke about Doppler navigation at the first of these meetings, which was held in May soon after his return from the convention.

Mr. Clegg, who was a pioneer of this technique at the Royal Radar Establishment, joined the Weapons Research Establishment, Salisbury, South Australia, in 1953, where he led a group engaged on the development of a low-power continuous-wave Doppler navigation aid designed to meet a requirement of the Royal Australian Air Force.

At the other meeting, Mr. A. W. Pybus gave an illustrated lecture entitled 'An introduction to the microwave-valve family', in which he most successfully drew a family tree explaining the relationships between the various types of microwave valve discussed at the convention and summarized their present state of development.

At a third specialist meeting, inspired by The Institution's convention on ferrites, Mr. D. W. Griffin introduced a series of short talks by members of the staff of the Weapons Research Establishment on 'The fundamentals and uses of ferrites'. The South Australia Oversea Committee have been pleased with the attendance at these meetings, and it is hoped to include more in programmes for future sessions as the occasion arises.

At their last meeting for 1958 the Committee elected Prof. E. O. Willoughby as Chairman and Mr. E. E. Story as Honorary Secretary for the 1958–59 Session. Messrs. W. S. Joyner, B. C. Chase and J. W. Crompton were elected ordinary members of the Oversea Committee. J. W. C.

OVERSEA ATTENDANCE REGISTER

DURING the period 16th December 1958 to 16th January 1959, these members called at the Institution building and signed the Attendance Register of Oversea Members:

ASHE, D. A. (Lower Hutt, N.Z.)
BOTTOMS, R. F. (Ipoh, Malaya)
BOWKER, H. C. (Calcutta, India)
CAMPBELL, C. G. (Kampala, Uganda)
COLLINS, P. T. (Nairobi, Kenya)
FIGUEIREDO, B. F. de (Bombay, India)
GATT, J. S. (Tarxien, Malta G.C.)
GRIFFITHS, J. H. (Tanganyika)
HARPER, R. F. (Lagos, Nigeria)
HATFIELD, G. A. (Lagos, Nigeria)
PERERA, K. K. Y. W. (Colombo, Ceylon)
TRAFFORD, W. M. (Singapore)